BME Design-Fall 2021 - Nicholas Jacobson
Complete Notebook

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HAOCHEN WANG

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Team contact Information

KENZIE GERMANSON - Oct 19, 2021, 6:33 PM CDT

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Project description

Nicholas Jacobson - Oct 20, 2021, 9:56 AM CDT

Course Number: BME 200/300

Project Name:

iPhone Virtual Reality Training Model for Microsurgical Practice

Short Name:

iPhone VR team

Project description/problem statement:

To design a microsurgical training tool using a smartphone lens set up capable of creating depth and high quality resolution comparable to a surgical microscope for training purposes.

This training model will make microsurgical training less expensive and more accessible to a wide range of users. It eliminates the need for an expensive surgical microscope by replacing it with a smartphone. The prototype will utilize the zoom functionality of the smartphone for the surgeon to clearly see sutures and tissues up close. By using a smartphone, it is also possible to stream the training to Zoom or a similar platform so training can occur virtually. The design will minimize lag time between the recording phone and projecting device for simultaneous view of both the trainee and observers, while increasing spatial awareness and depth perception via binocular live video.

About the client:

The team's clients are Dr. Ellen Shaffrey and Dr. Samuel Poore. They are both plastic surgeons at the UW Hospital in Madison, Wisconsin. They are looking for a way to affordably train many microsurgery students in a way that is similar to using a real microscope.

2021/09/17 - First Client Meeting

HAOCHEN WANG - Sep 23, 2021, 1:58 PM CDT

Title: First Client Meeting

Date: 09/17/2021

Content by: Haochen Wang

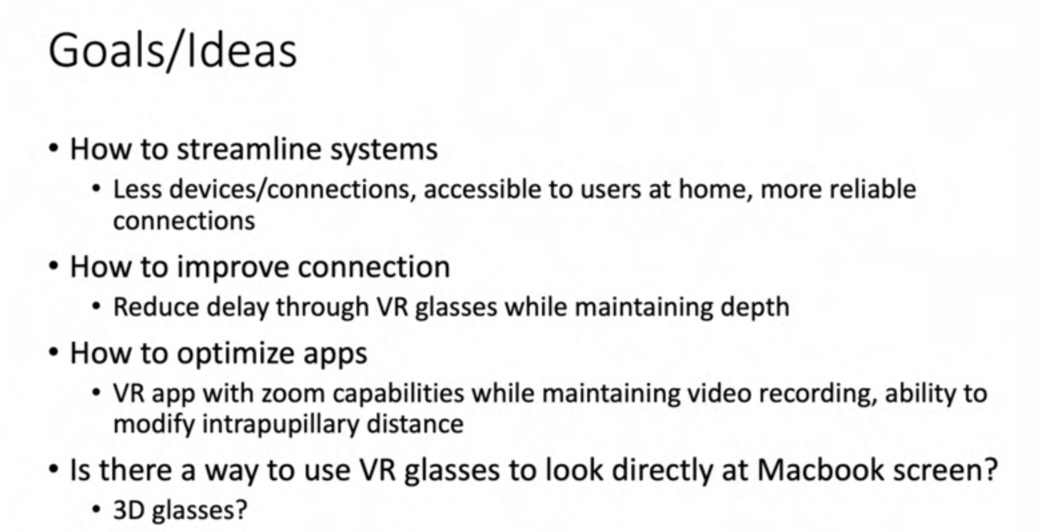
Present: The Smartphone VR Team, the Smartphone VR clients, Dr. Block

Goals: To establish expectations and to gain knowledge on the progress made on the project

Content:

1. Introduction on the project
    1. Microsurgeon uses a microscope for arteries, nerves, lymphatic vessels during surgeries. They magnify 30x (.2-.4 mm up to 2 mm blood vessel) for breast implant, finger connection. Needs practice to be good and safe. Requires equipment $300,000 up to 30x scope currently used in the O.R. Zeiss scopes
    2. Exoscope project; external camera viewing on the monitor, wearing goggles e.g.: Orb Eye
    3. Aim to use phones (utilizing the magnifying power, same quality of magnification to the scope)
        1. Practice at home
        2. Global health microsurgery practice in less developed areas
        3. Virtual training program
2. Current models
    1. Stand with phone
        1. Stand bought from amazon
        2. iPhone XR
        3. Clarity is incredible
        4. Look at a larger picture display via laptop connection
        5. Disadvantages
            1. Depth perception
            2. Delay (minimal via cord)
            3. iMovie app on MacBook (size limited to the phone size)
    2. VR model
        1. Reality aid App
            1. Creating a dual image
            2. Light source component, allowing separation and shrinking the image
            3. Provides a full screen view
        2. disadvantage
            1. Third component to the model
            2. Delay in processing into the VR system
        3. Computer to a second phone

        1. Share system wireless
        2. Duet
        3. But increases delay
        4. Now requires a second phone
    4. Google VR set ($7)
3. Goals/Ideas



    1. Computer display (watch, recording, share) large screen
    2. WIFI and Bluetooth creates significant delay
        1. Drone system control
    3. Glass-wear to change the view/depth perception
    4. Affordability
    5. Apply to both Apple and Android
    6. Adjusting zooming and focus
4. Current progresses
    1. Able to create a prototype of the app
    2. Not able to try real time
    3. Need universal solution
5. Questions prepared for the client
    1. Expectations for progress from previous teams
        1. Can set up a novel solution different from the previous team
        2. Can pursue a different approach
    2. Access to documents from previous teams
        1. Will sent out
    3. In-person try-out of previous deliverables (will be scheduled)
    4. Depth perception form microscope
        1. Multiple lens system

        2. X-scope uses a 3D goggle
    5. Lens quality
    6. Google cardboard VR set
        1. Provided a depth perception
        2. No peripheral vision
        3. Required multiple connection, the delay is a larger issue
    7. Budget?
        1. (Updated 09/22, this will be determined after a meeting among the clients)
    8. Have tried lens attachments
        1. Made for real-size objects, but not for microsurgeries

Conclusions/action items:

1. Incorporate meeting notes into PDS
2. Continue research on the existing design that the clients mentioned during the meeting

2021/09/22 - Second Client Meeting (Lab Tour)

HAOCHEN WANG - Sep 23, 2021, 1:42 PM CDT

Title: Second Client Meeting

Date: 09/22/2021

Content by: Haochen Wang

Present: Phone Virtual Team, Weifeng Zen

Goals: To have better understanding on the difficulties that the clients may encounter with smartphone and on their expectations

Content:

1. Disadvantages with smartphones
   1. Location of the sutures cannot be identified, since there is no depth perception for monocular vision
   2. Lack of 3D perception makes it difficult to safely operate on blood vessels
   3. Time consumption and video quality (mainly from the depth perception part) makes it impossible to use monocular video recording from smartphones for surgeries on human subjects
2. Issues to be solved for this project
   1. Delay when streaming video to screen (0.5s is already problematic, since slight movement has significant impact on microsurgery)
   2. Depth perception
3. The team then tried on a simple task (moving 5 pieces of suture from one location to another, with tweezers) with microscope (*model number unknown, needs to be asked for*) and iPhone 11
   1.

Subject	Microscope (s)	iPhone (s)	Percent Change (%)
Kenzie	22.43	28.00	24.83
Haochen	29.45	50.00	69.78
Nicholas	32.99	21.00	-36.34
Henry	21.68	31.00	42.99
Mitchell	20.00	17.40	-13.00
Cameron	18.70	31.75	69.79
Weifeng	9.00	N/A	N/A

Table 1: Time used in the task with microscope and smartphone, observe that there is overall increase in time spent on the task with monocular vision.

2. Observe that there is obvious increase in time spent on the task when using a smartphone comparing to a microscope
3. Ambiguity in the z-directional location of the tweezer tip is claimed by most of the group members, one group member had issues with the y-direction, and both of the locations may due to depth perception issues

    4. This may be also due to the location of the camera, which worth paying attention to in the project design

4. Difficulties experiences as a trainee for microsurgery
    1. The equipment was hard to control under microscope, and this was even more obvious under smartphone camera
    2. The suture is extremely thin, almost invisible with naked eye
    3. The microscope that the team used was hard to adjust for the magnification and pupil distance
    4. It is hard to use the microscope with prescription glasses on, so using a phone/monitor may have advantage over traditional microscope
5. Using iPhone 11
    1. 2X magnification
    2. Comparing to 4X magnification of the microscope, yet which is much further away from the station
6. Issues with the Google cardboard
    1. The screen of the installed smartphone is too close to the eyes
    2. Cannot really see anything from the screen
7. Requirement
    1. At least 10.2 M pixel resolution
    2. Being able to see the myo suture

Conclusions/action items:

1. Continue research based on the meeting notes
2. Incorporate the meeting notes into the PDS

2021/10/01 - Third Client Meeting

HAOCHEN WANG - Oct 20, 2021, 3:14 AM CDT

Title: Third Client Meeting

Date: 10/01/2021

Content by: Haochen Wang

Present: Phone Virtual Team, All clients

Goals: To introduce proposed designs and discuss progresses that have been made

Content:

1. Discussed what the team learned during last advisor meeting
2. Introduced design ideas
3. There is sufficient funds from Dr. Poore's lab (there's no specific cost requirement)
4. Next Friday (8th) at 5 pm for client meeting

Conclusions/action items:

1. Continue research based on the meeting notes
2. Incorporate the meeting notes into the PDS

2021/10/08 - Fourth Client Meeting

HAOCHEN WANG - Oct 20, 2021, 3:19 AM CDT

Title: Fourth Client Meeting

Date: 10/08/2021

Content by: Haochen Wang

Present: Phone Virtual Team, All clients

Goals: To discuss available resources for the project

Content:

1. Discussed current chosen design
2. Discussed current difficulties
    a. Target cost ~ $500
    b. Optimal distance ~ 1 foot
    c. Additional supplies: cord, iPhone will be sent out later
    d. Request for the slides presented in the first client meeting
    -

Next meeting 5 pm Friday

Conclusions/action items:

1. Continue research based on the meeting notes
2. Incorporate the meeting notes into the PDS

2021/10/22 - Fifth Client Meeting

HAOCHEN WANG - Dec 15, 2021, 12:06 AM CST

Title: Fifth Client Meeting

Date: 10/22/2021

Content by: Haochen Wang

Present: Phone Virtual Team, All clients

Goals: To discuss available resources for the project

Content:

1. Went over the preliminary report
2. iPhone 13 is available
3. 50x magnification
4. Portrait mode allows to zoom to 3x
5. Attachment piece will be offered
6. Target budget now increased up to 1 grand or 2
7. Goal is to get the prototype in December, actually do trials with the prototype
8. The lenses can be tried out in the lab
9. The phone is at maximum zoom
10. First week of November to show to get the design finalized
11. Get the parts ordered within two weeks

Conclusions/action items:

1. Plan future action according to the meeting notes
2. Start work on prototyping

2021/11/12 - Sixth Client Meeting

HAOCHEN WANG - Dec 15, 2021, 12:11 AM CST

Title: Sixth Client Meeting

Date: 11/12/2021

Content by: Haochen Wang

Present: Phone Virtual Team, All clients

Goals: To discuss current progress for the project

Content:

1. Went over the progress
2. Equipment
    a. Phone stand
3. Software
    a. Quicktime viewer on Mac
    b. Reality AI on the phone

Conclusions/action items:

1. Plan future action according to the meeting notes
2. Start work on prototyping

2021/09/10 - Advisor Meeting

HAOCHEN WANG - Sep 10, 2021, 2:50 PM CDT

Title: 1st Advisor Meeting

Date: 09/10/2021

Content by: Haochen Wang

Present: The iPhone team, Dr. Block

Goals: To set up expectations and get suggestions from the advisor

Content:

1. Setting up expectations from the client:
   1. Minimum goal: check off boxes at the end of the presentation
   2. Stretched goals
   3. Subdivide the project, and each member has part of the project as theirs
   4. Think about developing environment: what are the things that are already out there
   5. Check out the previous archives
2. Go to medical seminar on Monday – Mark Grismal (MRI, piloting with Microsoft, holo-lens for surgical planning (HSLC 1345 4:00 sept 13)
   1. Beyond the client's needs
   2. More info about the project: https://www.cleveland.com/business/2019/11/first-interactive-holographic-brain-map-could-make-surgery-more-precise-in-the-future.html
3. Dr. Block wants some contribution from each member to different aspects of the project (i.e.: Where got stuck, progresses, such that we know where everyone's at during the advisor's meeting)
4. Team leader should distribute the work well, dividing the whole project into different parts and assigning each to team members
5. This course is not sequential, so you could try something as a sophomore. Push on, since there is no course for each specific project.

Conclusions/action items:

Complete the tasks for the first day of BME 200/300.

Review meeting notes.

Setup meeting time with the advisor and the client.

2021/09/17 - Second Advisor Meeting

HAOCHEN WANG - Sep 23, 2021, 1:47 PM CDT

Title: Second Advisor Meeting

Date: 09/17/2021

Content by: Haochen Wang

Present: The Smartphone VR Team, Dr. Block

Goals: To discuss thoughts on the project and expectations from the advisor

Content:

1. Surgery is expensive
    1. Not constrain too much at the beginning
    2. Cost may be reduced upon repetitive application of the deliverable
2. Need to know basics on 3D
    1. Apps on the phones (what's already there)
    2. Obtain access to the cameras from the same phone
3. The team brainstorm possible solutions
    1. Utilizing multiple lenses from the same phone for video recording
    2. Attaching lens system onto the recording phone to achieve a 3D effect
    3. Modifying the current video processing algorithm to achieve higher efficiency
    4. Applying available software/APPs for video processing
    5. Utilizing

Conclusions/action items:

Begin research upon suggestions from Dr. Block

2021/10/01 - Third Advisor Meeting

HAOCHEN WANG - Oct 20, 2021, 3:15 AM CDT

Title: Third Advisor Meeting

Date: 10/01/2021

Content by: Haochen Wang

Present: The Smartphone VR Team, Dr. Block

Goals: To discuss thoughts on the project and expectations from the advisor

Content:

1. Discussed proposed design ideas
2. Keep refining PDS on how to adjust the depth perception
3. Can always reduce the cost later
4. Think about how the design is different from the available solution
5. Think of letting a third person manipulate the view (focus, magnification, etc.)
6. The advisor refers Lab Archive to know individual progress, the weekly report is used to judge how each individual contributes the team work to build a prototype

Conclusions/action items:

Continue work on the project based on instructions from the advisor

2021/10/08 - Fourth Advisor Meeting

HAOCHEN WANG - Oct 20, 2021, 3:17 AM CDT

Title: Fourth Advisor Meeting

Date: 10/08/2021

Content by: Haochen Wang

Present: The Smartphone VR Team, Dr. Block

Goals: To discuss expectations on the preliminary presentation by the advisor

Content:

1. Discussed the presentation assignment
    a. First slide: introduction
        i. Meaningful to the project
        ii. Surgical magnification design routes
        iii. Surgical process gap
        iv. 2:30 min
        v. Not a class on everything
        vi. Our client wants this, and this is what we should do
        vii. Cost effective manner, gap, access to the training design
        viii. We are looking at two cameras because this is crucial for depth perception etc. presenting but not teaching
    b. Design ideas
    c. Which one is best
        i. Defensible design matrix
        ii. Why you put the categories in the weights
        iii. How they are measure
        iv. Rationale
        v. This is what we gonna do in the semester but not just saying that highest score wins
    d. Conclusion
        i. Future not just saying building the prototype
        ii. Talk about the challenges
        iii. Be specific
        iv. How to test
        v. Say sth specific
2. Get the slides done by Wednesday to get feedback
3. Challenges in the design
    a. Correct lens
    b. Describe precisely in engineering terms
    c. Use engineering terms (FOV, focal length)
    d. Size of the lens
    e. Separation
    f. One lens with two views making sense?
        i. Constructive interference?
        ii. Realize this is a challenge

Conclusions/action items:

Work on preliminary presentation based on the meeting notes

2021/11/01 - Fifth Advisor Meeting

HAOCHEN WANG - Dec 15, 2021, 12:04 AM CST

Title: Fifth Advisor Meeting

Date: 2021/11/01

Content by: Haochen Wang

Present: The design team, Prof. Block

Goals: Get feedback and suggestions from the advisor on testing

Content:

1. Discussed current design and planned ways to test the design
2. Replicate the picture several times to show how light travels
3. Try cover one of the mirrors during testing to determine the effectiveness of the prototype
4. Consider how precision on each parameter during fabrication affect the final result
5. The inner mirrors only need to rotate, the outer mirrors need to be translatable and rotatable
6. From prof block in chat: https://www.youtube.com/watch?v=nAAEtQ6qvcE
7. Talk to Dr. Rogers about the optic bench
8. Consider projecting the video on another device
9. Compare the f-stop of the pinhole camera to the iPhone 8 camera

Conclusions/action items:

Work on prototyping based on the meeting notes

2021/11/5 - Show and tell and Advisor meeting

KENZIE GERMANSON - Nov 05, 2021, 6:40 PM CDT

Title: Show and tell

Date: 2021/11/5

Content by: Kenzie Germanson

Present: Kenzie, Henry, Haochen, Cameron, and Mitchell

Goals: Gather ideas from peers of how to test and adjust the mirrors

Content:

Ideas from peers:

1. Have arms on the mirrors to rotate them and adjust to what the user sees
    a. Have a mechanism to lock the arms in one spot so that the angles of the mirrors are quantifiable
2. Quantify testing parameters
    a. How to measure depth and show that our design increased depth perception
        i. Idea: speed test, if you can move the sutures faster, the depth is better
        ii. Drawback, someone who has done the suture moving more will be faster regardless of depth
3. Possibly use a mechanism similar to those in watches to turn the mirrors

Block says just focus on creating the 3D image for now, adjustability will come later

Conclusions/action items:

Look into how adjustments on watches work and see if that is applicable for our mirror adjusting.

Figure out how to quantify depth perception to see if our designs improve over time.

2021/11/12 - Sixth Advisor Meeting

HAOCHEN WANG - Dec 15, 2021, 12:09 AM CST

Title: Sixth Advisor Meeting

Date: 2021/11/12

Content by: Haochen Wang

Present: The design team, Prof. Block

Goals: Get feedback and suggestions from the advisor on testing

Content:

1. Went over the preliminary report
2. iPhone 13 is available
3. 50x magnification
4. Portrait mode allows to zoom to 3x
5. Attachment piece will be offered
6. Target budget now increased up to 1 grand or 2
7. Goal is to get the prototype in December, actually do trials with the prototype
8. The lenses can be tried out in the lab
9. The phone is at maximum zoom
10. First week of November to show to get the design finalized
11. Get the parts ordered within two weeks

Conclusions/action items:

Work on prototyping based on the meeting notes

Materials and Expenses

Nicholas Jacobson - Dec 15, 2021, 12:08 PM CST

Title: Materials and Expenses

Date: 12/06/2021

Content by: Nicholas Jacobson

Content:

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Component 1								
Neodymium Magnets	Magnets to mount the mirrors onto for testing purposes.	Magnet Source	NA	11/18/21	1	5.98	5.98	NA
Component 2								
Clear Acetate Sheets	Clear sheets to print a parallax barrier on, didn't end up being used in final design.	Cricut	NA	11/02/21	2	7.11	14.22	NA
Component 3								
50 1inx1in Mirrors	Mirrors to be used in our final design	Jetec	B096FWCKTH	11/02/21	1	7.99	7.99	Link
TOTAL:								**$28.19**

2021/11/19-Testing on most feasible parameters

HAOCHEN WANG - Dec 12, 2021, 1:17 PM CST

Title: Fabrication and testing on the most feasible parameters

Date: 11/19/2021

Content by: Haochen Wang

Present: All team members, Dr. Zeng

Goals: To determine the most optical location and angles of the mirrors while fabricating a working prototype

Content:

Testing on most feasible parameters	**Observations**
I. Purpose A. The protocol aims to find the most feasible parameter based on the proposed final design and the calculations B. While the optic simulation with software demonstrated failure in the mathematical model, the team decided to directly investigate the most optical parameters with the smartphone, with trial-and-error tests II. Materials and equipment A. Mini size square mirror adhesive (1 in by 1 in, x 50 pieces) B. Memory foam (x1) 1. Size may vary, as long as it is large enough to mount the mirrors 2. Serve as the fixation for the mirrors	11/19/2021 II.b.: Used a larger one provided by the clients II.e.: not accessible during the testing, used pins to secure the smartphone

C. Ruled index cards
D. iPhone 8 (x1)
E. Smartphone stand (x1)
F. Caliper (x1)
G. Paper Clip (x1)
   1. Served for calibration in ImageJ
H. Sharpie (x1)
I. Protractor (x1)
J. T-shaped/drawing pins
K. Thumbtacks (at least 4)
L. Graph paper with grids
M. Glue and clear tape
N. Scissors/knives

III. Procedure

A. On a piece of graph paper, draw out desired locations of mirrors based on the calculation (use the caliper and the protractor to get more accurate measurement)
   1. Also mark the horizontal center line and the horizontal lines at the proximal edge of the mirrors
B. Use protractor, beginning with the mirror edge proximal to the camera lens, draw rays centered at the edge with 5 degrees of increments
   1. Draw the angle references for all four mirrors
C. Pin the graph paper onto the memory foam
D. Stroke the edge of mirror with the size as

II.j.: obtained a box of T-shaped pins

Lower half of the Mi(2) is cracked off, thus the imaged formed on it should be trimmed for better visibility

Measurements:

Mirror/ Position	Width (mm)	Length (mm)
Mi(1)/ Left	6.38 6.51 6.61	24.73 24.69 24.68
Mi(2)/ Right	5.51 5.31 5.63	24.81 24.77 24.78
Mo(1)/ Right	12.62 12.54 12.57	24.72 24.74 24.71
Mo(2)/ Left	13.09 13.99 13.08	25.01 24.81 24.79

Discarded the original plan, used 2-T-pins and magnet to hold the mirror stable

calculated on the notecards 1. 5.53 mm x 22.29 mm for the inner mirrors, and 11.63 mm x 22.29 mm for the outer mirrors 2. Repeat for all four mirrors 3. Leave some extra space vertically on the notecards, such that the mirrors can be pinned onto the memory foam upon the extra space 4. Cut off the pieces	Cut with scalps (2 blades used)
E. Stick the mirror adhesives to the notecard pieces prepared in D 1. Then cut the mirrors to fit the shape of the notecards	0.70 mm (flat, with marks on both sides to the measured position) 0.85 mm (vertical)
2. **CAUTION**: be careful with splashing of the mirror pieces and potential cut due to sharp edges	Working distance is estimated, not accurate. It is observed better image quality and duplication is achieved with further working distance.
F. Pin the mirrors at the desired locations with thumbtacks	

G. Fold the notecard pieces such that the extra part is on the reflective side, then pin on these white spaces
H. Place drawing/T-shape pins on the non-reflective side to hold the mirrors upright
I. On a stable platform, mount the phone stand such that the smartphone and the attachment are aligned horizontally
J. Secure the smartphone to the stand
K. Draw a line with sharpie on the paper clip, then measure the diameter (thickness) with the caliper
L. Secure the paperclip on the memory foam, making the marked part visible from above
M. Adhere several pieces of graph paper to simulate the desired workspace (141 mm x 188 mm)
N. Stick the workspace to a wall
O. Adjust the position of the memory foam, such that it is 305 mm (the desired working distance) away from the workspace
P. Turn on the smartphone camera, adjust distance of the mirrors from the camera lens and their angles, such that two views of the same portion of the workspace present on the smartphone at x1 magnification
Q. If the desired outcome cannot be achieved,

Observed working space width:

Left: 3-11 cm marks

Right: 6-14 cm marks

Observe that the left view and right view are not perfectly aligned. Use the right half as the reference for prototyping.

Measured FOV: 6 cm wide by 7.5 cm high

The images appear blurry on the side and edges

$$\eta = 13\ mm$$

(Distance between the camera lens and the inner mirror vertex)

$$r = 6\ mm$$

(Radius of the camera lens)

$$x = 8.4\ mm$$

(Vertical distance between the proximal edge and the assumed center line)

$$z_1 = 4.1\ mm, \alpha_1 = 52.8°$$

(Horizontal distance between the proximal edge and the assumed 0-distance base perpendicular to the center line, and the angle between the outer mirror

adjust the mirror lengths by covering/lengthening the mirrors R. Take a picture from the iPhone 8 S. Take a picture from the top of the setting with another phone 1. Make sure to include marked paperclip T. Repeat steps F-N for x2 optical zoom then for additional x5 digital zoom (total x10 magnification) U. Clean up the testing station IV. Data processing A. Take notes of the precision of the measuring equipment B. Export photos taken above the station to ImageJ C. Using diameter of the paper clip as reference, measure the lengths and parameters (distances) specified in the mathematical model D. Measure angle of the mirrors relative to the horizontal lines E. From the pictures taken by iPhone 8, evaluate distortion, effective area of workspace and image quality F. Calculate error margin in component preparation and measurements	with respect to the center line. Both values are for the left/first outer mirror) $z_2 = 3.4\,mm, \alpha_2 = 52.1°$ (Same parameters as above, for the right/second outer mirror) $\phi_1 = 61°, \phi_2 = 66°$ (Angle between the first/left and second/right inner mirror and the central line) $\beta = 94.6°$ (It was found that the smartphone lens is in fact tilted at this angle from the center line) $Mi = 6\,mm, Mo = 13\,mm$ (The length of the inner and outer mirrors) Caliper: +/- 1 mm Protractor: +/- 0.5 deg Ruler: +/- 0.5 mm

Conclusions/action items:

1. Use the data obtained to fabricate the prototypes for final testing

2. Based on observations from this experiment, the concept of splitting view with two pairs of mirrors is proved to work.

2021/12/02 - Fabrication Protocol

HAOCHEN WANG - Dec 12, 2021, 12:15 PM CST

Title: Testing on the most feasible parameters

Date: 12/02/2021

Content by: Haochen Wang

Present: Haochen Wang

Goals: To fabricate a working prototype for testing on the following day

Content:

Fabrication protocols for prototypes	**Observation**
I. Purpose A. To specify the protocol for prototyping II. Material and equipment A. Mini size square mirror adhesive (1 in by 1 in, x 50 pieces) B. Cardboard box (size may vary) C. Smartphone D. Caliper (x1) E. Sharpie (x1) F. Protractor (x1) G. T-shaped/drawing pins H. Thumbtacks (at least 4) I. Glue and clear tape J. Scissors/knives III. Procedure A. Disassemble the cardboard box into several large, flat pieces B. On the disassembled cardboard, stroke out the position of mirrors obtained from ImageJ • Also stroke the frame of the attachment C. Cut out the cardboard pieces	12/02/2021

• Prepare 2 side pieces and 2 base pieces in total D. Prepare the inner outer mirrors • Mark out the cutting line with a sharpie that are 6 mm (for inner mirrors) or 13 mm (for outer mirrors) away from a side • Cutoff the mirrors with a knife • BE CAUTIOUS FOR risk of being cut by sharp pieces E. Attach glue pads onto the base cardboard pieces F. Mount the mirrors onto the glue pads, then assemble the attachment frame with tape G. Adjust the position of the mirrors such that the edges of the mirrors align with the reference lines H. Check the result with a smartphone aligned with the attachment, adjust the mirrors as necessary until two identical views can be observed from the camera	Prototype 1 failed Prototype 1 adopted the right half pieces (right inner mirror and right outer mirror) and assumed symmetry in the attachment design. No identical views can be formed on the camera through camera position, camera magnification and mirror position were adjusted. A second prototype was made based on all measurements from ImageJ, fully adopting the camera position, angle, left and right halves of the mirror system. The second prototype was successful in forming two identical images, thus becoming the final model used for further testing.

Conclusions/action items:

1. Use the second prototype for testing and demonstration with the clients
2. Draw ray tracing diagrams to further evaluate the optical properties of the working prototype

2021/12/08 - Measurement on the delay

HAOCHEN WANG - Dec 12, 2021, 1:35 PM CST

Title: Testing on time lag in streamlining video captured by the proposed hardware design

Date: 12/08/2021

Content by: Haochen Wang

Present: Haochen Wang

Goals: To measure the delay of the final design when streaming to the end users (testing on the Effectiveness criteria of the PDS)

Content:

I. Purpose
   1. To test whether the proposed final design by the team can improve time lag comparing to the design proposed by the previous team
II. Material and equipment
   1. Personal computer (i7-11800H, 32GB RAM)
   2. Zoom (Version 5.7.8)
   3. Kinovea (Version 0.9.5)
   4. ASUS portable monitor (1980 x 1080 resolution, 60 Hz refresh rate)
   5. iPad pro (1080P 60fps recording capability)
   6. Smartphone (2460 x 1080 resolution, 1080P 60fps recording capability, Snapdragon 778G, 8GB RAM)
   7. Prototype MK II
III. Procedure
   1. Connect the portable screen to PC, then play a sample music video on it
   2. Align the smartphone with the attachment, such that part of the music video playing on the portable screen can be captured
   3. Using the video meeting feature on Zoom, project the view captured by the smartphone onto the portable screen
   4. Adjust position of the APPs on the portable screen, such that all three views can be captured by the iPad
   5. Play the video, then record with iPad
   6. Import the video recorded by iPad to Kinovea, adjust frame by frame and find several landmarks in determining the delay in streaming
      1. Find the corresponding frame when the same effect is observed on the streamed video
      2. Subtract the time and record as time delay
   7. Take the average

Conclusions/action items:

1. Perform the experiment and report the values for poster presentation

2021/12/08 - Modification on the calculation and formulas

HAOCHEN WANG - Dec 12, 2021, 12:26 PM CST

Title: Modification on the calculation and formulas

Date: 12/08/2021

Content by: Haochen Wang

Present: Haochen Wang

Goals: To develop a working mathematical model that is suitable for predicting parameters required for most models of smartphones

Content:

Modification on the calculation and formulas

I. Purpose
   1. To modify the mathematical model for parameter calculation such that the outcome fits observation
   2. To develop a MATLAB script such that the parameters can be customized to fit various models of smartphones

II. Materials and equipment
   1. Personal computer (model may vary)
   2. MATLAB

III. Procedure
   1. Import data collected from testing
   2. Ray Optics Simulation, a web-based simulation app developed by Tu *et al.*

IV. Disclaimer
   1. Mathematical model and equations are adapted from Seal *et al.* (2005) [1]
   2. MATLAB code used to make initial calculation on desired parameters are developed by a team member

V. Procedure
   1. Use obtained distance data and plug back to the equations used in the MATLAB code
   2. Find coefficients such that the angles () match the observed values
   3. Alter the parameters initialized in the MATLAB code, then perform a ray simulation based on the parameters to confirm feasibility of the mathematical model

Conclusions/action items:

1. Due to time limits of the project, this portion of the testing protocol will not be executed in this semester.
2. The final parameters are close to the calculated results, so minor change are expected to be made in the future.

2021/12/08 - Measurement on the delay

HAOCHEN WANG - Dec 12, 2021, 1:35 PM CST

Title: Testing on time lag in streamlining video captured by the proposed hardware design

Date: 12/08/2021

Content by: Haochen Wang

Present: Haochen Wang

Goals: To measure the delay of the final design when streaming to the end users (testing on the Effectiveness criteria of the PDS)

Content:

Testing on time lag in streamlining video captured by the proposed hardware design	**Observation**

I. Purpose II. To test whether the proposed final design by the team can improve time lag comparing to the design proposed by the previous team III. Material and equipment IV. Personal computer (i7-11800H, 32GB RAM) V. Zoom (Version 5.7.8) VI. Kinovea (Version 0.9.5) VII. ASUS portable monitor (1980 x 1080 resolution, 60 Hz refresh rate) VIII. iPad pro (1080P 60fps recording capability) IX. Smartphone (2460 x 1080 resolution, 1080P 60fps recording capability, Snapdragon 778G, 8GB RAM) X. Prototype MK II XI. Procedure XII. Connect the portable screen to PC, then play a sample music video on it XIII. Align the smartphone with the attachment, such that part of the music video playing on the portable screen can be captured XIV. Using the video meeting feature on Zoom, project the view captured by the smartphone onto the portable screen XV. Adjust position of the APPs on the portable screen, such that all three views can be captured by the iPad XVI. Play the video, then record with iPad XVII. Import the video recorded by iPad to Kinovea, adjust frame by frame and find several landmarks in determining the delay in streaming a. Find the corresponding frame when the same effect is observed on the streamed video b. Subtract the time and record as time delay XVIII. Take the average	12/08/2021 Music video is 1080P 60fps Chose the frame when first verse of the lyrics disappears on the smartphone, the frame when the second verse disappears, and the frame when the third verse emerges Results: First lyrics disappearing: 6.59 s Projected disappearing: 6.81 s Second lyrics disappearing: 11.60s Projected disappearing: 11.80s Third lyrics appearing: 12.03s Projected appearing: 12.24s 1. 0.22s 2. 0.20s 3. 0.21s Average: 0.21s

Conclusions/action items:

1. This is an improvement comparing to the results from the previous team, where they did not use live video for testing

2. Though processing of the frames may increase the time delay, the only limiting factor of delay in this experiment is Zoom, which will be replaced with direct connection between recording device and the projecting device with WIFI or Bluetooth
3. Report the average value in poster presentation

2021/10/01- Microsurgery in Elderly Population

MITCHELL BENYUKHIS (benyukhis@wisc.edu) - Oct 19, 2021, 8:08 PM CDT

Title: Microsurgery in Elderly Population

Date: 2021/10/01

Content by: Mitchell Benyukhis

Present: Mitchell Benyukhis

Goals: Consider safety restrictions of potential design idea on patient

Content:

- Evaluated 194 consecutive patients from 18 centers, aged 65 or older, who received an elective microsurgical flap between April 2018 and April 2019
- Flap survival in the whole study group was 92.3%
  - Slightly lower than rate reported for general population
- Increased risk of complications and a longer hospitalization in patients aged ≥75

Conclusions/action items:

- Consider implementation of strategies to test safety level of trainee.
- Implement super sensitive safety sensors to ensure that adequate safety level is maintained.

Cordova, Adriana, et al. "Safety of Reconstructive Microsurgery in the Elderly Population: A Multicentric Prospective Study." *Journal of Plastic, Reconstructive & Aesthetic Surgery*, 2021, https://doi.org/10.1016/j.bjps.2021.05.048.

2021/10/13- Measuring Ergonomic Risk by Using Wearable Technology

MITCHELL BENYUKHIS (benyukhis@wisc.edu) - Oct 19, 2021, 8:09 PM CDT

Title: Measuring Ergonomic Risk by Using Wearable Technology

Date: 2021/10/13

Content by: Mitchell Benyukhis

Present: Mitchell Benyukhis

Goals: Consider safety restrictions of potential design idea on surgeon

Content:

- Ergonomic risk was assessed by calculating the percentage of time spent in a specified range of risk categories for each body segment
- Surgeons spent 29% of procedure time in high-risk neck positions
- Surgeons spend a longer time in high-risk positions while using the standard operating microscope
- Utilizing a 4K-3D exoscope during male fertility microsurgery may mitigate surgeon ergonomic risk and poor posture.

Conclusions/action items:

- Modify design ideas to make them more ergonomically friendly towards the surgeon/trainee
- Create system more similar to an exoscope than a microscope

Gonzalez, Daniel, et al. "Measuring Ergonomic Risk by Using Wearable Technology: A Comparison of a 4K-3D EXOSCOPE to the Operating Microscope in Male Fertility Microsurgery." *Fertility and Sterility*, vol. 116, no. 3, 2021, https://doi.org/10.1016/j.fertnstert.2021.07.265.

2021/10/03- Hand Motion Analysis Tool

MITCHELL BENYUKHIS (benyukhis@wisc.edu) - Oct 19, 2021, 8:10 PM CDT

Title: Hand Motion Analysis Tool

Date: 2021/10/03

Content by: Mitchell Benyukhis

Present: Mitchell Benyukhis

Goals: Formulate new designs with ideas from existing ones

Content:

- Candidates asked to perform end-to-end anastomoses on cryopreserved rat aorta
  - (average diameter 1.86 mm +/- 0.18) using 9-0 nylon.
- Hand monitors intended to provide feedback
- Compared experience level and hand motion
- Hand movement decreased as number of performed anastomoses's increased
- Inverse correlation found between hand motion and anastomoses's performed
- Results of motion analysis used to provide feedback and alter testing simulation

Conclusions/action items:

- Implement a feedback provider once practice simulation is complete
- include a sensor on design for hand movement to judge accuracy

Kim, E., Chawla, S., & Ghanem, A. (2021). Mastering microsurgery: A novel benchmarking tool for microsurgical training. *Journal of Plastic, Reconstructive & Aesthetic Surgery*. https://doi.org/10.1016/j.bjps.2021.09.010

2021/10/08- Depth Perception with Single Camera

MITCHELL BENYUKHIS (benyukhis@wisc.edu) - Oct 19, 2021, 8:10 PM CDT

Title: Depth Perception with Single Camera

Date: 2021/10/08

Content by: Mitchell Benyukhis

Present: Mitchell Benyukhis

Goals: Bypass the current depth perception struggle

Content:

- View one sees viewable area
- View two sees dead area
- There is a common field of view
- Mirrors replace double cameras; only one camera is used
- Duplicate image funnels into one to allow for best depth perception
- Outer mirrors reflect onto inner mirrors

Conclusions/action items:

- Take advantage of mirrors to eliminate the need for a second Iphone
- Alter angled of mirrors to allow for best depth perception
- Implement funneling system to combine views of mirrors

Seal, Johnathan R. “Depth Perception with a Single Camera.” *Ist.massey.ac.nz*, 21 Nov. 2005, https://www-ist.massey.ac.nz/dbailey/sprg/pdfs/2005_ICST_96.pdf.

2021/10/14- Microsurgery Trainee Recommendations

MITCHELL BENYUKHIS (benyukhis@wisc.edu) - Oct 19, 2021, 8:10 PM CDT

Title: Microsurgery Trainee Recommendations

Date: 2021/10/14

Content by: Mitchell Benyukhis

Present: Mitchell Benyukhis

Goals: Consider current trainee requirements and implement them into the design

Content:

- 91.66% of experts recommended a 1:1 ratio for microscopes per trainee
- 66.66% recommended 40 h course training time
- 33.33% of experts thought 8 h is the proper duration of ex vivo training
- 75% of educators recommended the use of 2 forceps (one curved), a curved needle holder, microsurgical scissors, vessel dilator and 2 clamps for each student.
- 1 educator per 3 students is advisable
- Recommended extensive training on non-living tissue before animals

Conclusions/action items:

- Incorporate a product that doesn't require the need for an educator to be physically present
- Make product adhere to majority voted restrictions for training simulation

Ghanem, Ali, et al. “International Microsurgery Simulation Society (IMSS) Consensus Statement on the Minimum Standards for a Basic Microsurgery Course, Requirements for a Microsurgical Anastomosis Global Rating Scale and Minimum Thresholds for Training.” *Injury*, vol. 51, 2020, https://doi.org/10.1016/j.injury.2020.02.004.

2021/10/01- Dual Vision Headset Design

MITCHELL BENYUKHIS (benyukhis@wisc.edu) - Dec 13, 2021, 8:10 PM CST

Title: Dual Vision Headset Design

Date: 2021/10/01

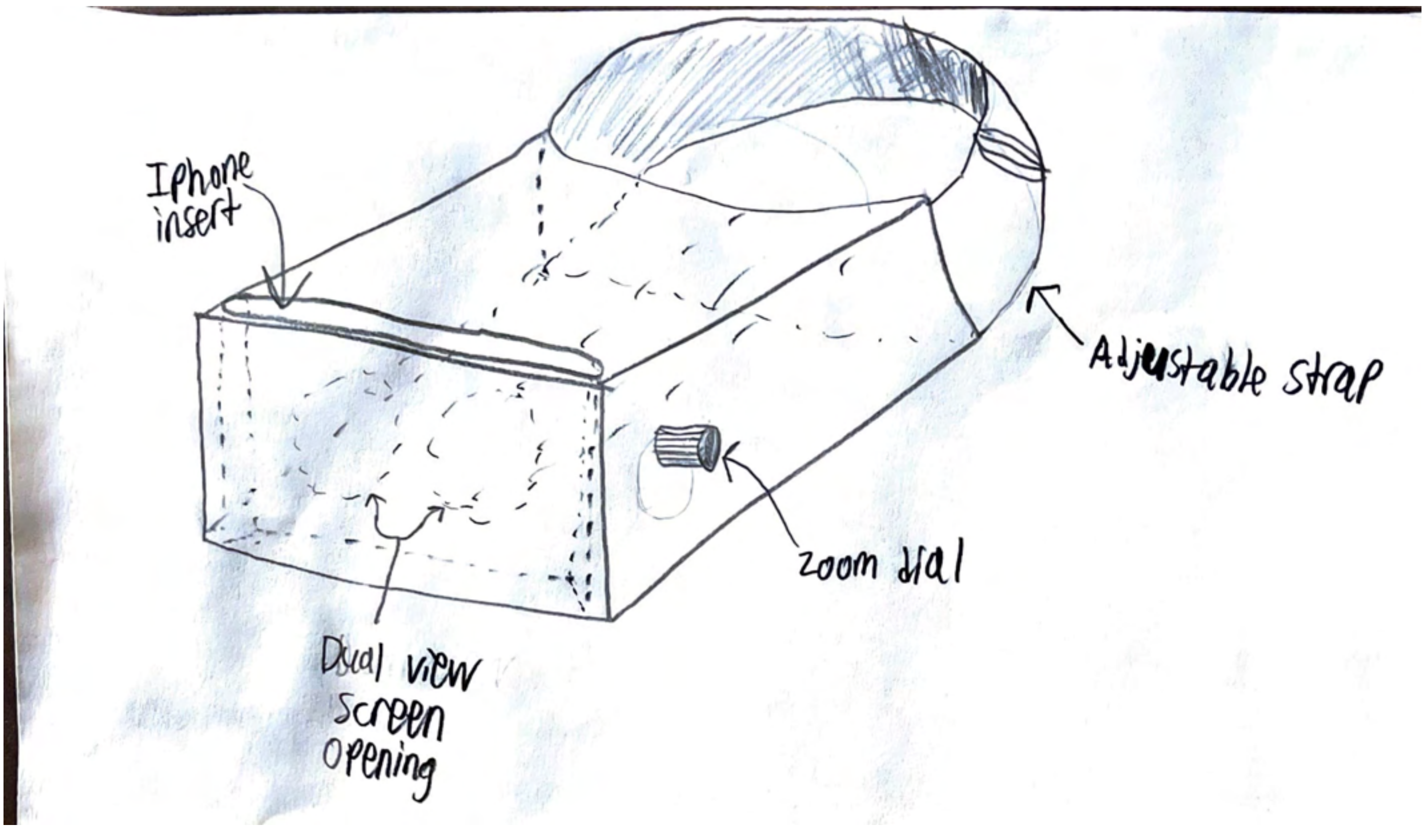
Content by: Mitchell Benyukhis

Present: N/A

Goals: To introduce a dual vision lens into a headset

Content:

3in x 6in



Conclusions/action items:

- Rate design in design matrix
- Present design to client and team members

2021/12/05- Product Testing Protocol

MITCHELL BENYUKHIS (benyukhis@wisc.edu) - Dec 13, 2021, 8:25 PM CST

Title: Product Testing Protocol

Date: 2021/12/05

Content by: Mitchell Benyukhis

Present: N/A

Goals: To create testing protocol for real life implementation and analyzation.

Content:

Overall Test:

- Draw two 2’ x 2’ boxes side by side on a surgical sheet
- Place 8, 1mm long, sutures in left box
- Students will use tweezers to move sutures from left box to right box
- Time will start when student picks up tweezer
- Time will conclude when student puts down tweezer

Test Simulations 1:

- Collect a simple random sample of 100 first year medical students who are practicing microsurgery and split randomly into groups A and B, 50 students in each
- Both groups can practice the testing procedure using the microscope during normal training hours
- Group A is allowed to use the mirror prototype at home after normal training hours and during the weekend
- Group B is allowed to use no prototype after normal training hours, prior to the test
- After five days of training, the students will return the following week and be tested in the lab
- Allow both groups 3 attempts at the test and take average completion time and number of movements.

Analysis 1:

- Record Total time to complete the task
- Record Total hand movements
- Total grade 0-100
  - Time points start at 50, and 1 point is subtracted for every second over 25 seconds
  - Hand movement points start at 50, and 1 point is subtracted for every movement over 16 base movements

Conclusion 1:

- Evaluate the scores using a Student’s t-test for population means using a significance value of 0.05.
- H_0: Mean value of each student’s three scores in group A = mean value of each student’s three scores in group B
- H_A: Mean value of each student’s three scores in group A ≠ mean value of each student’s three scores in group B
- If our p-value for the Student’s t-test using the means of each students’ three scores is less than or equal to .05, we reject the null hypothesis and can conclude that there is significant statistical evidence that the means of the means of groups A and B are not the same. If the p-value is greater than .05, we have insufficient evidence to reject the null hypothesis and we can conclude that the values of the means of each group are similar.

Test Simulations 2:

- Collect a simple random sample of 100 first year medical students and split randomly into groups A and B, 50 students in each
- Group A is allowed to use mirror prototype during normal training hours
- Group B is allowed to use currently-used microscope during normal training hours

- After five days of normal training, both groups will return the following week and be evaluated using the testing method
- Allow both groups 3 attempts at the test and take average completion time and number of movements.

Analysis 2:

- Record Total time to complete the task
- Record Total hand movements
- Total grade 0-100
    - Time points start at 50, and 1 point is subtracted for every second over 25 seconds
    - Hand movement points start at 50, and 1 point is subtracted for every movement over 16 base movements

Conclusion 2:

- Evaluate the scores using a Student's t-test for population means using a significance value of 0.05.
- H_0: Mean value of each student's three scores in group A = mean value of each student's three scores in group B
- H_A: Mean value of each student's three scores in group A ≠ mean value of each student's three scores in group B
- If our p-value for the Student's t-test using the means of each students' three scores is less than or equal to .05, we reject the null hypothesis and can conclude that there is significant statistical evidence that the means of the means of groups A and B are not the same. If the p-value is greater than .05, we have insufficient evidence to reject the null hypothesis and we can conclude that the values of the means of each group are similar.

Conclusions/action items:

- Conduct testing protocol
- Conclude local testing and expand into global testing

2021/10/17 Depth Perception

CAMERON DIMINO - Dec 15, 2021, 1:14 PM CST

Title: Binocular depth perception and the cerebral cortex

Date: 2021/10/17

Content by: Cameron Dimino

Present:

Goals: Understand how depth perception is achieved.

Content:

content by Andrew J. Parker from "Nature Reviews Neuroscience". Published May 2007

- Humans and some other animals use their two eyes in coordination to support binocular depth perception. The left and right eyes obtain images of the visual scene from slightly different viewpoints, leading to small differences between the left and right images called binocular disparities.
- Measurement of the tuning functions of neurons in the visual cortex for disparity gives important information about how the visual stimulus influences the firing of neurons but does litle to reveal the roles of different neurons in binocular depth perception.
- Known features of binocular stereoscopic depth perception can be used to set up tests of the role of individual neurons and individual cortical areas.
- One early hypothesis was that the dorsal visual cortical pathways are pre-eminently responsible for binocular depth perception. Other views have assigned different roles to the dorsal and ventral streams.
- Neurons outside the primary visual cortex (V1) respond consistently to relative disparity. Neurons in both dorsal and ventral extrastriate visual areas respond to relative disparity.
- Binocular anticorrelation can be used to map the role of different sites in the visual cortex in the generation of binocular depth perception.

Conclusions/action items:

The main point that can be taken from this article is that you need 2 slightly different images from a different viewpoint to achieve depth perception. They can then be processed into one image that can achieve depth perception. We can draw inspiration on how to achieve depth perception by looking towards how it is done in our own brains.

2021/10/23 Stereoscopic Vision

CAMERON DIMINO - Dec 15, 2021, 1:27 PM CST

Title: Stereoscopic Vision Overview

Date: 2021/10/23

Content by: Cameron Dimino

Present:

Goals: Understand Stereoscopic vision

Content:

content from https://www.sciencedirect.com/topics/medicine-and-dentistry/stereoscopic-vision

- stereoscopic vision describes the ability of the visual brain to register a sense of three-dimensional shape and form from visual inputs.
- In current usage, stereoscopic vision often refers uniquely to the sense of depth derived from the two eyes. This usage excludes a number of things that might be considered stereoscopic vision, such as the sense of depth arising from the motion parallax generated when subjects translate themselves through the visual environment.
- Current usage also means that the term ‘stereoscopic vision’ tends to include a number of issues relevant to binocular vision that are unrelated to the perception of three dimensions. One example is singleness of vision: namely, the generation of perception of a single object by the two eyes by means of their co-coordinated use.
- Stereopsis is a powerful cue to depth that arises as a consequence of having two eyes that are laterally offset in the head. This means that each eye receives a slightly different image of the world, a fact one can easily confirm by holding a finger in front of the face, and looking at it with each eye in turn. The two retinal images generated at any instant are identical in most respects, except for a positional shift which makes it appear that the finger is jumping back and forth as one changes the viewing eye. This positional difference is illustrated in Figure 1, which shows a cluster of grapes as a stereo pair (one image for each eye, photographs taken from each eye's viewpoint). Notice that the upper grape of the central group of three occludes part of the background on the left (right-eye image) that is visible on the right (left-eye image).

Sign in to download full-size image

Figure 1. A stereoscopic image pair taken with two cameras. Right eye view on the left, left eye view on the right. To view, cross your eyes, until the two squares align, and focus on the middle image. Courtesy of Zeb Hodge, as posted on Flickr.

-
- These differences in image position are known as binocular disparity, and this is the information the brain uses to extract an estimate of the depth of an object or point, relative to where the observer is fixating. This disparity may also be thought of as the angular difference between a pair of points on the retinas.

Conclusions/action items:

The example of the grape in the article is what we are looking to achieve with our prototype. We are looking to get two slightly different images from our prototype. When processed, there should be a single image formed that has depth perception (could perhaps be processed with a VR headset)

2014/09/20 - Summary of Microscope notes sent by Client

CAMERON DIMINO - Sep 20, 2021, 1:22 PM CDT

Title: Summary of Notes sent by Client

Date: 09/20/2021

Content by: Cameron Dimino

Present:

Goals:

- summarize the docs sent by the client to the team about project

Content:

Resolution comparison of microscopes:

- magnification at 4x: 41-53 lp/mm

- max resolution: 51-118 lp/mm

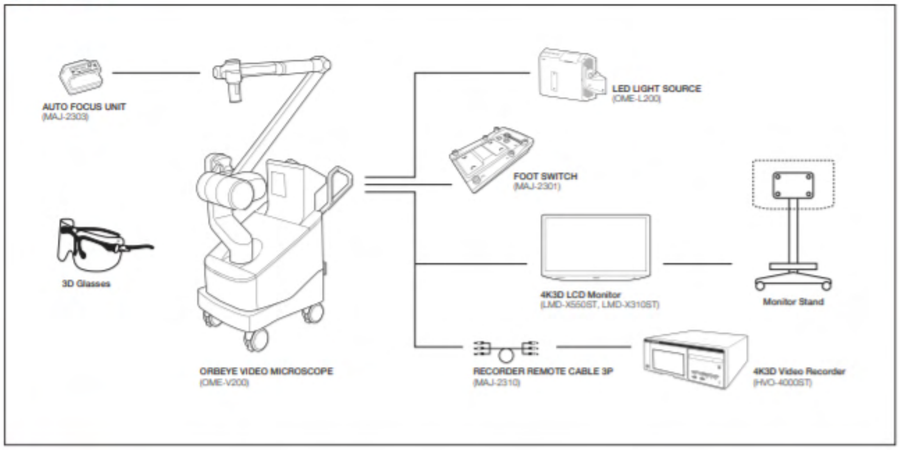
MM51 microscope:

- interchangeable objective lenses

- main binocular has iris diaphragm, used for depth of focus and resolution

Orbeye:

System Chart



Specification

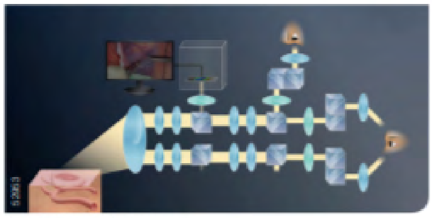
Power Supply	Voltage	AC 100 – 120 V, within ±10%
	Frequency	50/60 Hz, within ±1 Hz
	Input current	6.5 A
Size	Dimension	517 (Base width) × 623.5 (Base length) × 1,882 mm (Total height)
	Weight	216 kg
Focus	Method	Motorized focal length variation
	Focal length	220-550 mm
	Auto focus	Yes (MAJ-2303 is required)
Zoom	Drive system	Motorized zoom magnification change
	Magnification ratio	1:12 (Optical 1: 6, Digital 1: 1.5 or 1: 2)
Observation	Image sensor	4K
	Output formats	4K (3D/2D), HD (3D/2D)
	Signal output (transmission method)	3G-SDI, HD-SDI

About Fluorescence Modes and Filter Technology

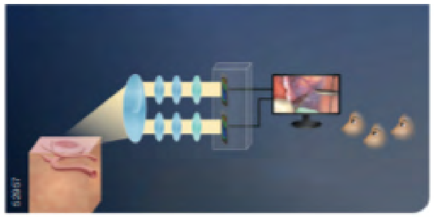
The ORBEYE 4K 3D orbital camera system fluorescence modes and filter technology benefit directly from the unique design of the system.

You will experience brighter fluorescence visualization than with traditional microscopes. Increased brightness is the result of three key design features:

1. Light passes through fewer optical lenses compared to an ocular-based microscope.

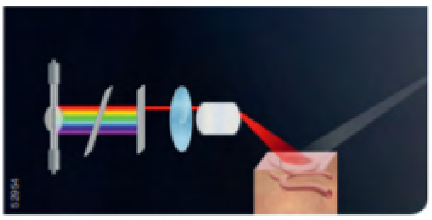


Standard surgical microscope

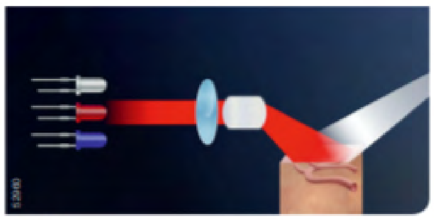


ORBEYE

2. The use of dedicated blue and red LEDs, rather than relying on filters removing light wavelengths from white light.



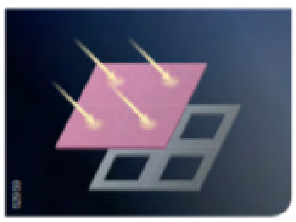
Standard surgical microscope



ORBEYE

3. The Exmor R CMOS image sensor made by SONY has the light-receiving surface located above the wiring layer. Therefore, most of the available light reaches the sensor.

Standard surgical microscope



ORBEYE

HoloLens:

- mixed reality glasses
- $3500
- already being implemented into the healthcare field

Conclusions/action items:

2021/10/1 Design concept 1

CAMERON DIMINO - Oct 19, 2021, 9:50 PM CDT

Title: Design 1: 3D app and 2nd camera

Date: 10/1

Content by:

Present:

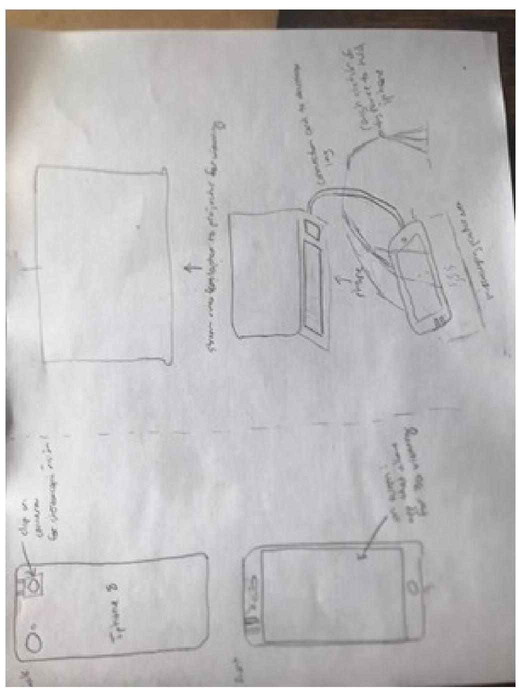
Goals:

Content:

In this design, a second camera is attached to the iphone. This second camera will be used to produce a 3D image. The 3D image will be generated in an app for the iphone that we will design. This feed from the iphone would then be streamed to a laptop which could then be projected on a projector.

Conclusions/action items:

CAMERON DIMINO - Oct 01, 2021, 1:17 PM CDT



DBCB63AA-6F1E-46B0-9CAF-7EB3E6C976A9.jpg(26.5 KB) - download

2021/10/11 Research on CMBFs

CAMERON DIMINO - Oct 19, 2

Title: Research on CMBFs

Date: 10/11/2021

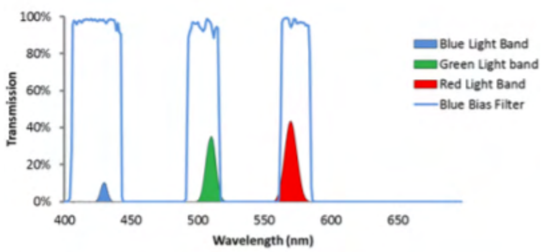
Content by: Cameron Dimino

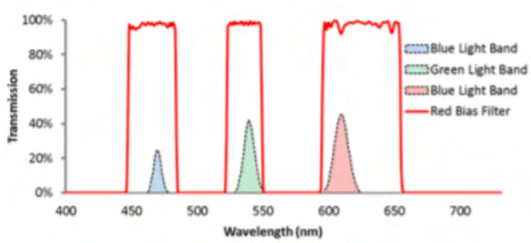
Present:

Goals: increase knowledge about CMBF design

Content:

https://trs.jpl.nasa.gov/bitstream/handle/2014/42269/11-5619.pdf?sequence=1:

- In an effort to miniaturize a 3D imaging system, we created two viewpoints in a single objective lens camera. This was accomplished by placing a pair of Complementary Multi-band Ba Filters (CMBFs) in the aperture area
- Two key characteristics about the CMBFs are that the passbands are staggered so only one viewpoint is opened at a time when a light band matched to that passband is illuminated, ar passbands are positioned throughout the visible spectrum, so each viewpoint can render color by taking RGB spectral images.
- Each viewpoint takes a different spectral image from the other viewpoint hence yielding a different color image relative to the other
- However, the staggering makes the CMBFs to skip some regions in the color band. For example, when a passband of one CMBF takes a place in the red band, a passband of the othe have to skip that red band
- However, the mismatched colors can be minimized through digitally correcting colors and choosing a right set of CMBFs
- 



Price: hundreds of dollars, sometimes 1000s

https://www.google.com/search?q=complimentary+multi+bandpass+filter&rlz=1C1CHBF_enUS913US913&source=lnms&tbm=shop&sa=X&ved=2ahUKEwiU9MfmgNjzAhWVPM0KHbAoCBMQ_AUoAnoECAEQBA&biw=160

Conclusions/action items:

The CMBF design could effectively produce a 3D image. However, a lot of time would have to be spent to determine the correct lens to purchase, and purchasing the lens would b The quality of the image may also not be up to the standards of the client the staggering of the CMBFs

2021/12/11 CAD Inner Mirror

CAMERON DIMINO - Dec 11, 2021, 3:19 PM CST

Title: 2021/12/11 CAD Inner Mirror

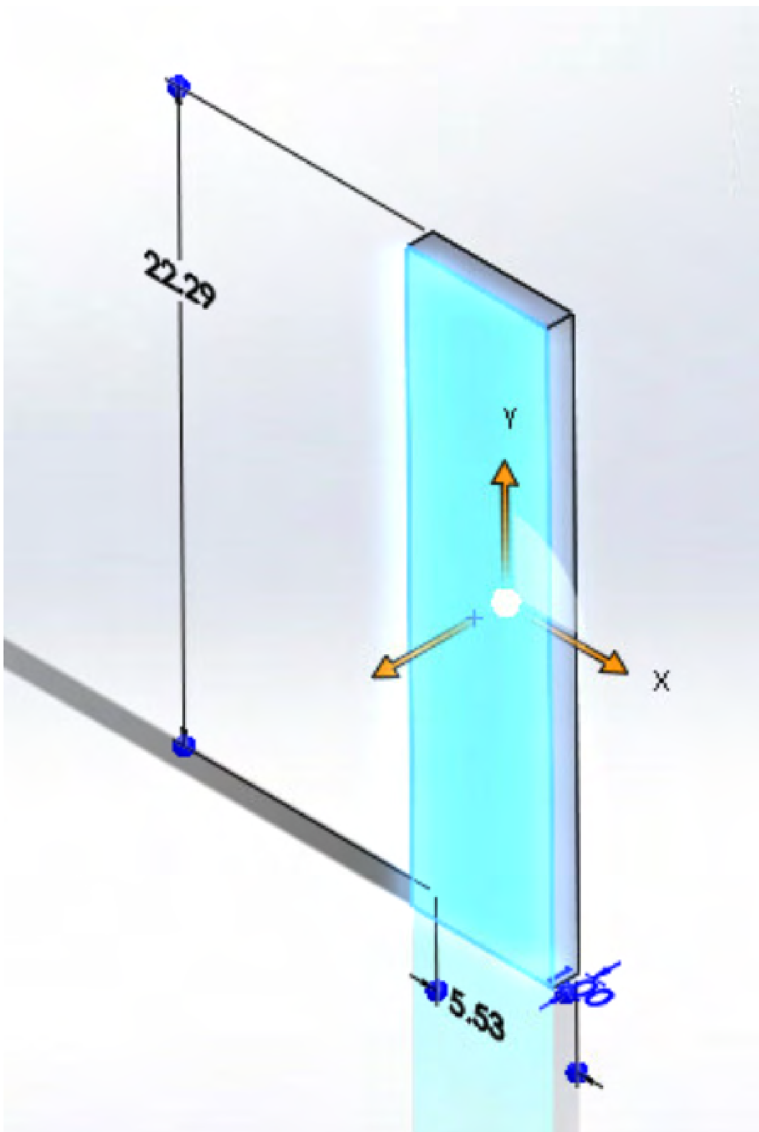
Date: 12/11/2021

Content by: Cameron Dimino

Present:

Goals:

Content:



- dimensions are in millimiters

- 1 millimeter thick

Conclusions/action items:

2021/12/11 CAD Outer Mirror

CAMERON DIMINO - Dec 11, 2021, 3:23 PM CST

Title: 2021/12/11 CAD Outer Mirror

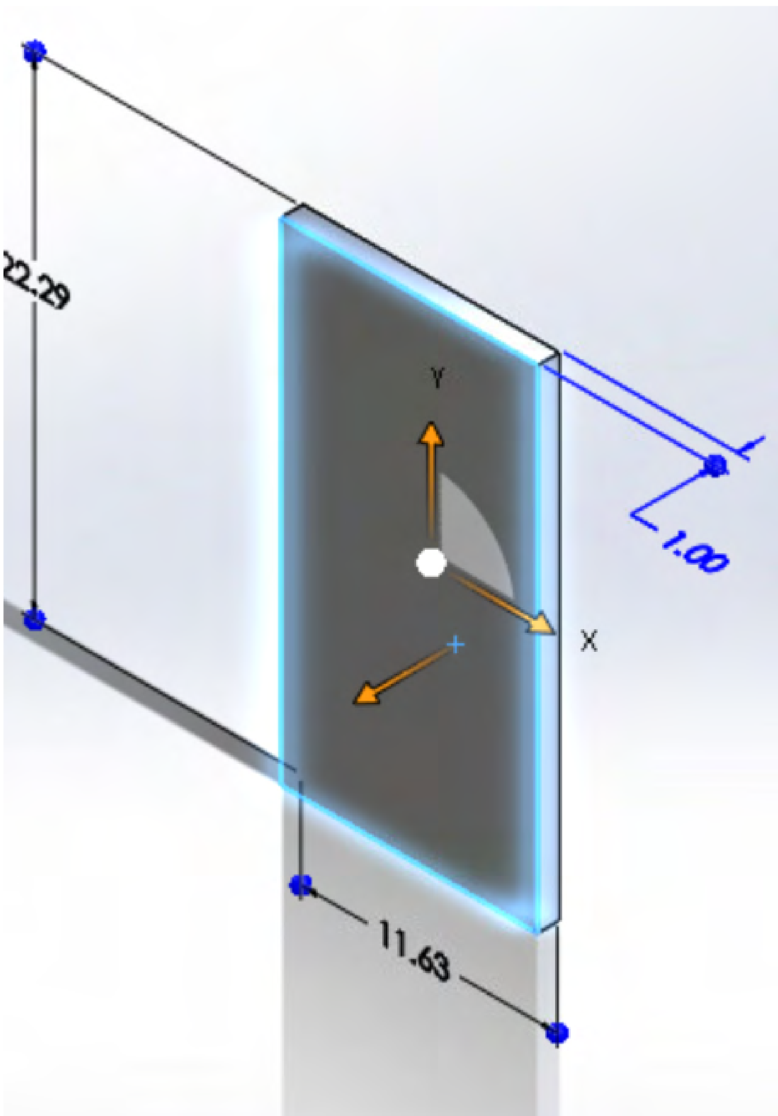
Date: 2021/12/11

Content by: Cameron Dimino

Present:

Goals:

Content:



- measurements in millimeters

Conclusions/action items:

2021/12/11 CAD Housing Box

CAMERON DIMINO - Dec 11, 2021, 3:29 PM CST

Title: 2021/12/11 CAD Housing Box

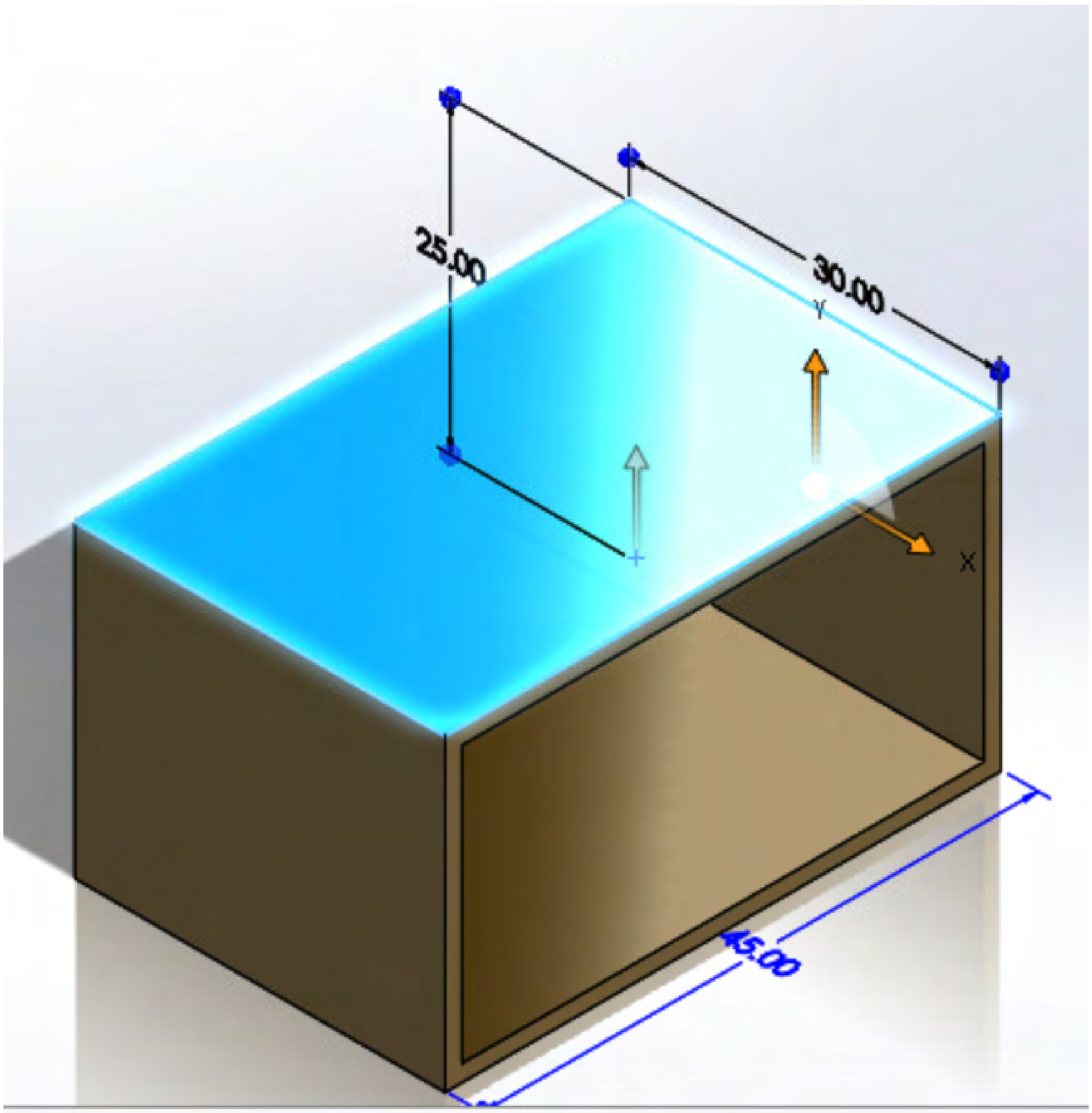
Date: 12/11/2021

Content by: Cameron Dimino

Present:

Goals:

Content:



- measurements in millimeters

Conclusions/action items:

2021/12/11 CAD Prototype Assembly

CAMERON DIMINO - Dec 11, 202

Title: 2021/12/11 CAD Prototype Assembly

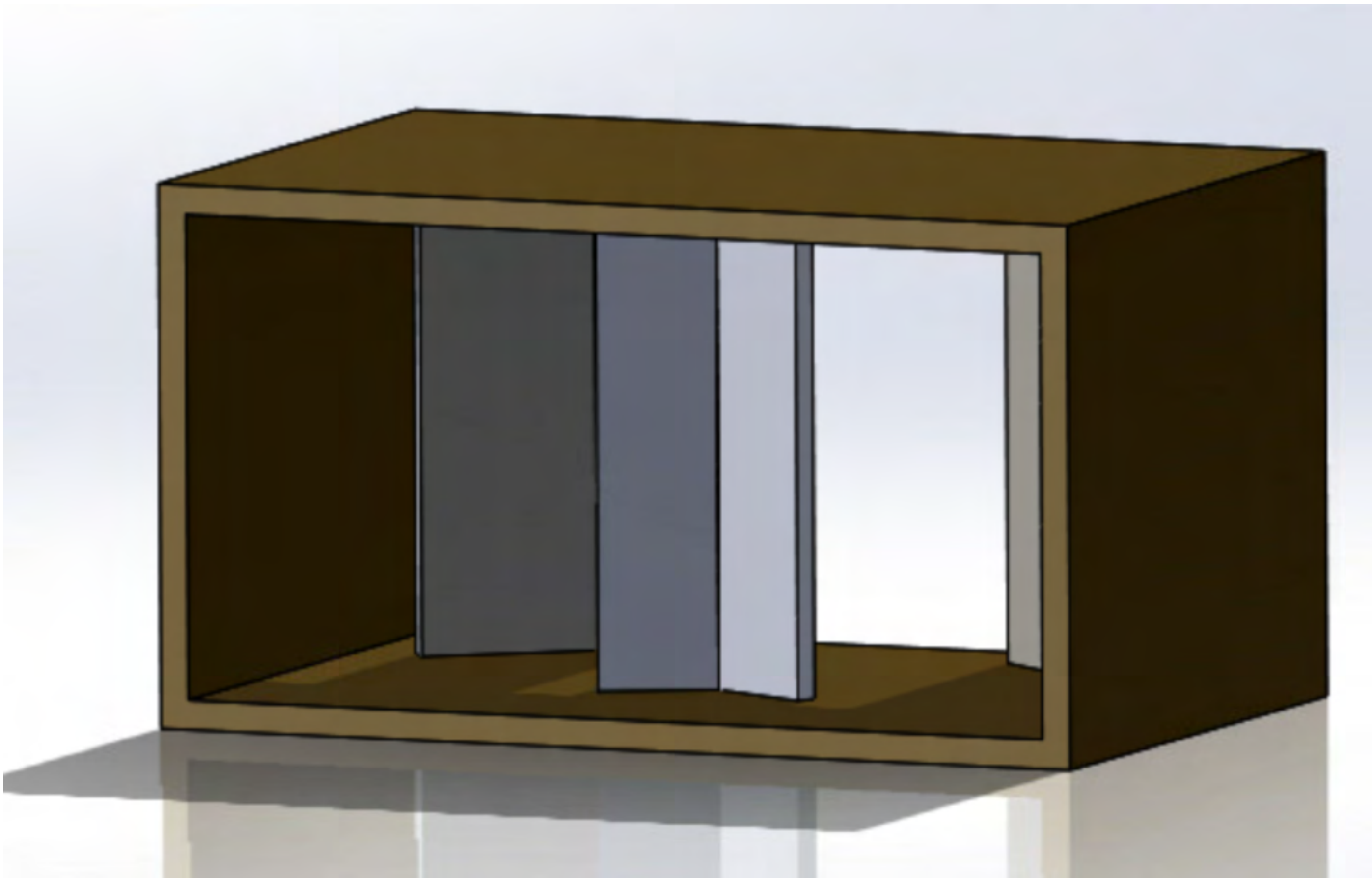
Date: 2021/12/11

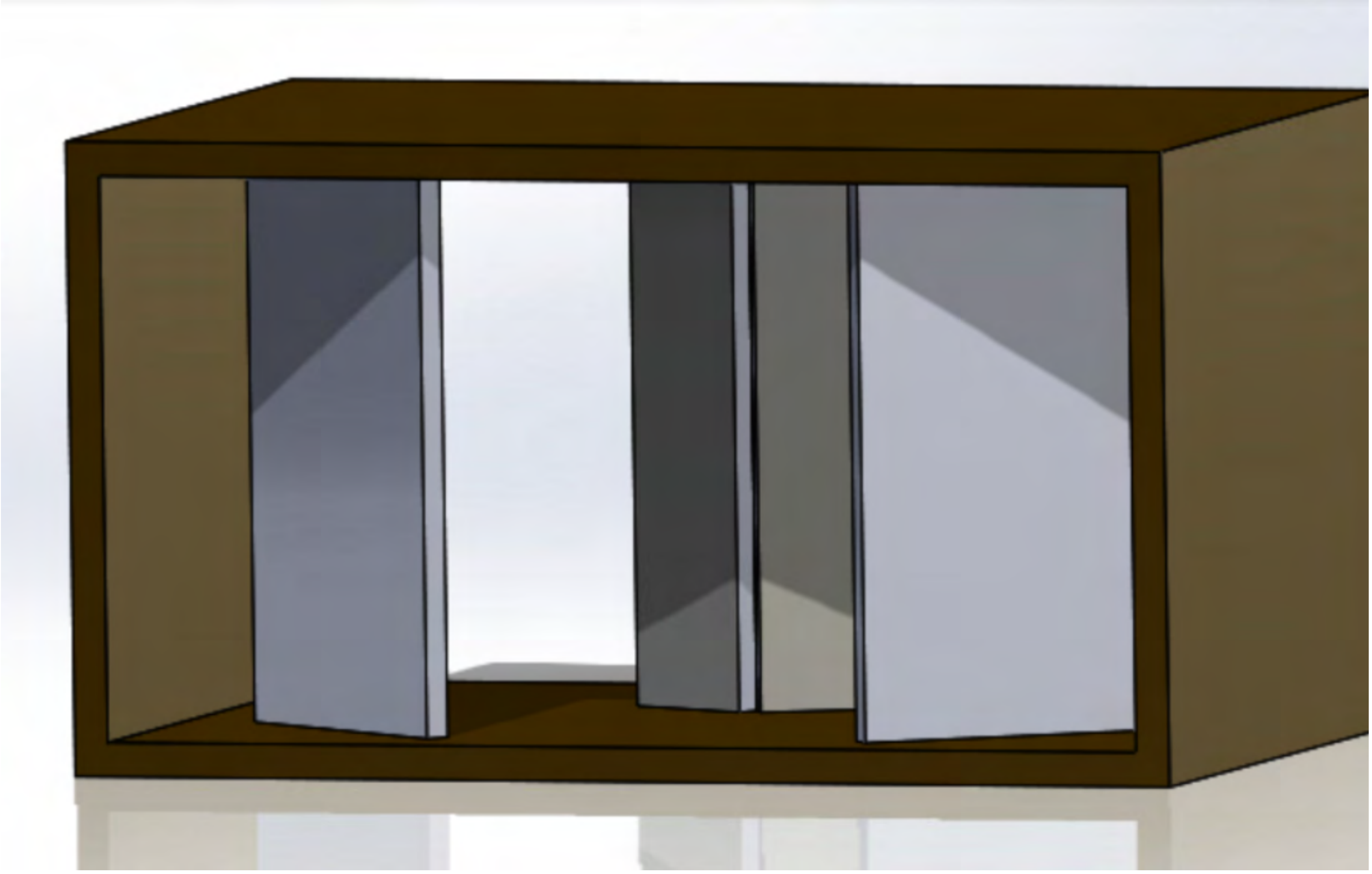
Content by: Cameron Dimino

Present:

Goals:

Content:





Conclusions/action items:

2021/12/14 CAD Prototype Drawing

CAMERON DIMINO - Dec 14, 2021, 9:00 PM CST

Title: 2021/12/14 CAD Prototype Drawing

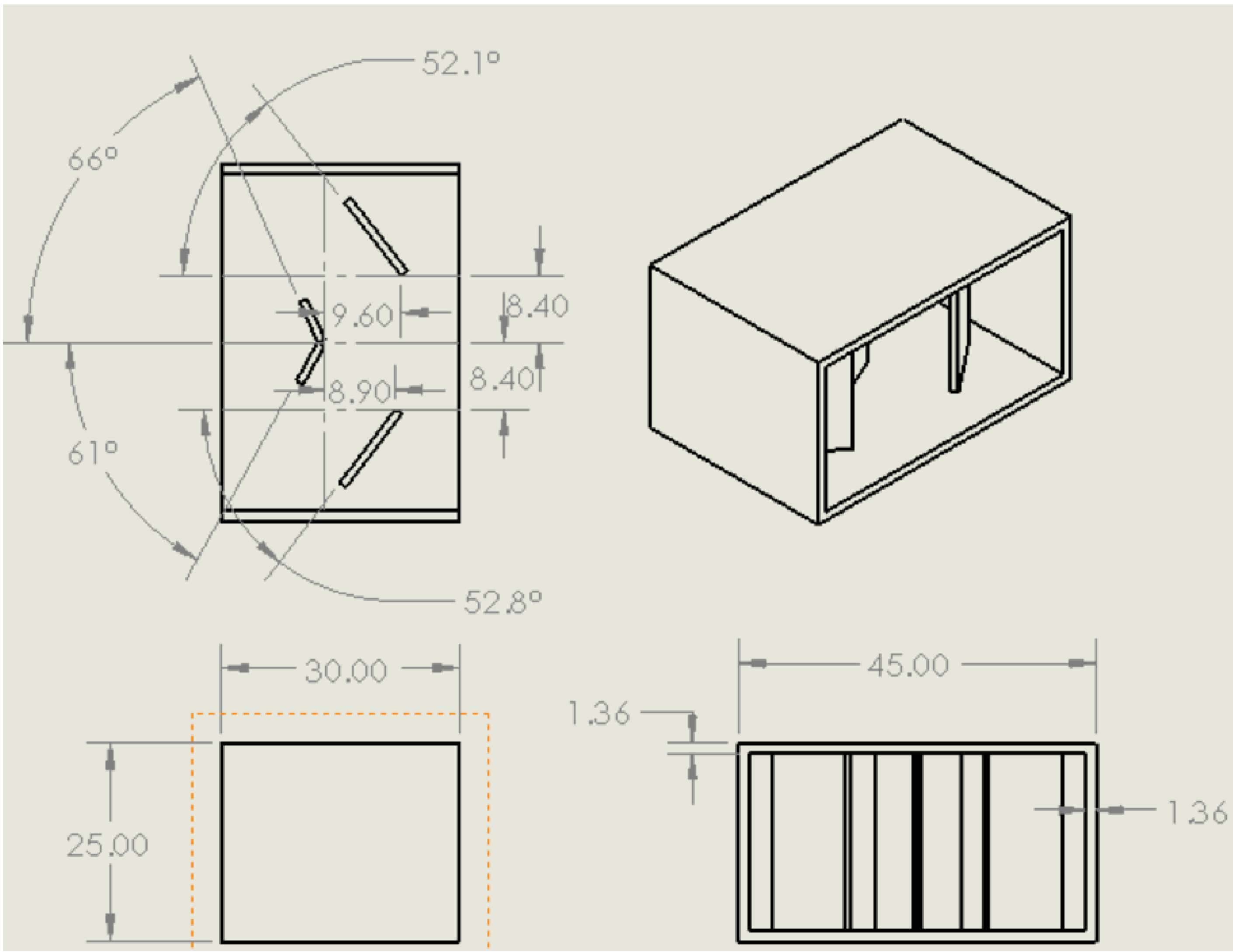
Date: 2021/12/14

Content by: Cameron Dimino

Present:

Goals:

Content:



- done in Solidworks using Prototype Assembly

Conclusions/action items:

2021/09/28 - Parallax barrier engineering for image quality improvement in an autostereoscopic 3D display

Nicholas Jacobson - Oct 20, 2021, 10:18 AM CDT

Title: Parallax barrier engineering for image quality improvement in an autostereoscopic 3D display

Date: 2021/09/28

Content by: Nicholas Jacobson

Goals: Find out how parallax barriers work to see if we can incorporate one into our design,

Content:

- Stereoscopic display allows an individual to see two different images as one.
- Provides viewer with 3D images by sending two angled views of an object to the eyes which is perceived by the brain as 3D.
- Many current stereoscopic display technologies force the user to wear eyeglasses or a headset.
- Optical plate placed in close proximity to the display source allows for 3D vision without wearing anything.
- Parallax barrier is a slit patterned mask over the display. Causes two different angled images to be sent to each eye.
- Downside to parallax barrier is cross talk, an unwanted image reaching a certain eye. For example light designated for left eye reaching right eye.

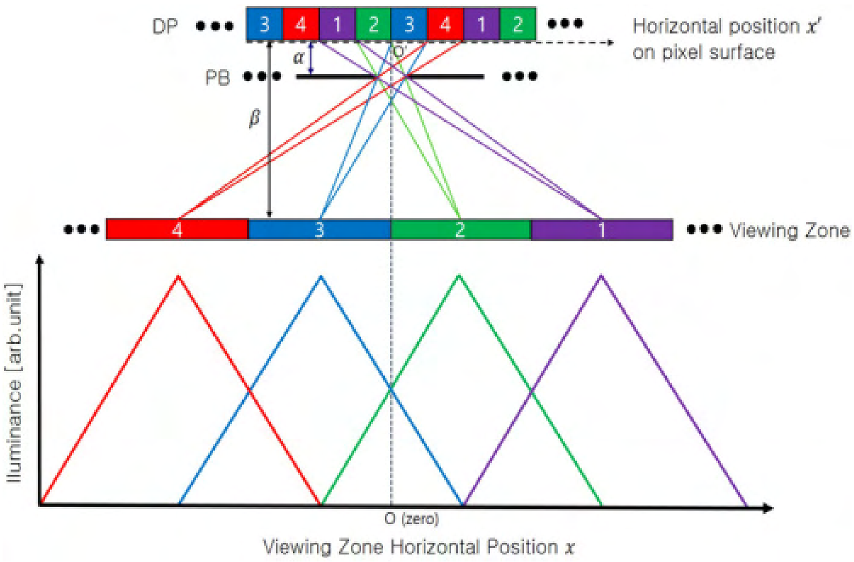


Figure 1 - Example of a stereoscopic display with 4 viewing zones.

- Parallax displays have restrictive viewing areas because of the narrow angle at which the light will hit the correct eye.

S.-K. Kim, K.-H. Yoon, S. K. Yoon, and H. Ju, “Parallax barrier engineering for image quality improvement in an autostereoscopic 3D display,” *Optics Express*, vol. 23, no. 10, pp. 13230–13244, May 2015, doi: 10.1364/OE.23.013230.

Conclusions/action items: A parallax barrier would be a viable option for our project but more research needs to be done to find an achievable way to create one.

2021/10/03 - Auto-stereoscopic 3D displays with reduced crosstalk

Nicholas Jacobson - Oct 20, 2021, 10:19 AM CDT

Title: Auto-stereoscopic 3D displays with reduced crosstalk

Date: 2021/10/03

Content by: Nicholas Jacobson

Goals: Find a way to create an auto-stereoscopic parallax display.

Content:

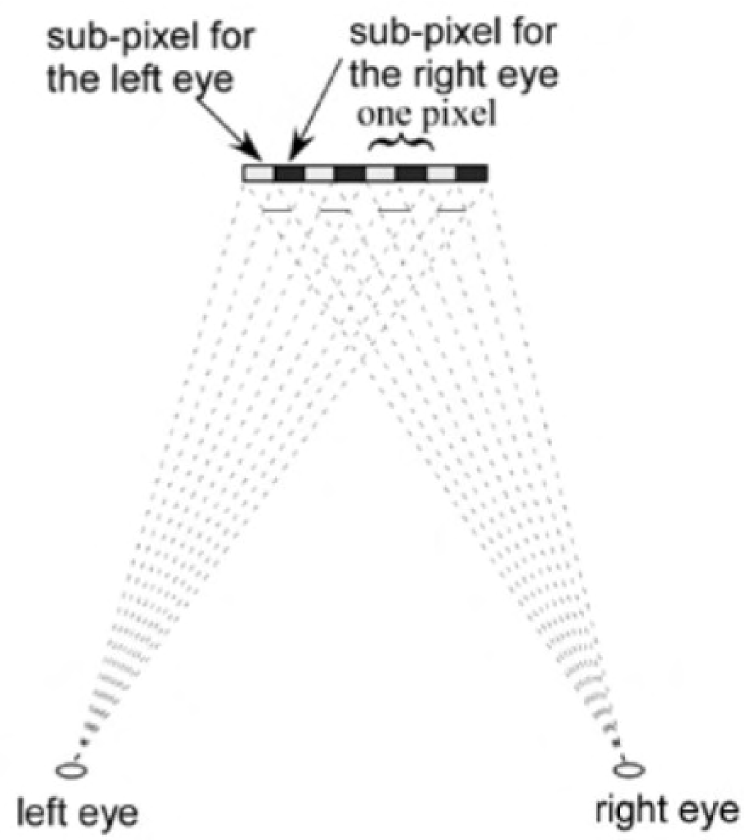


Figure 1 - Example of an autostereoscopic display using a flat parallax barrier.

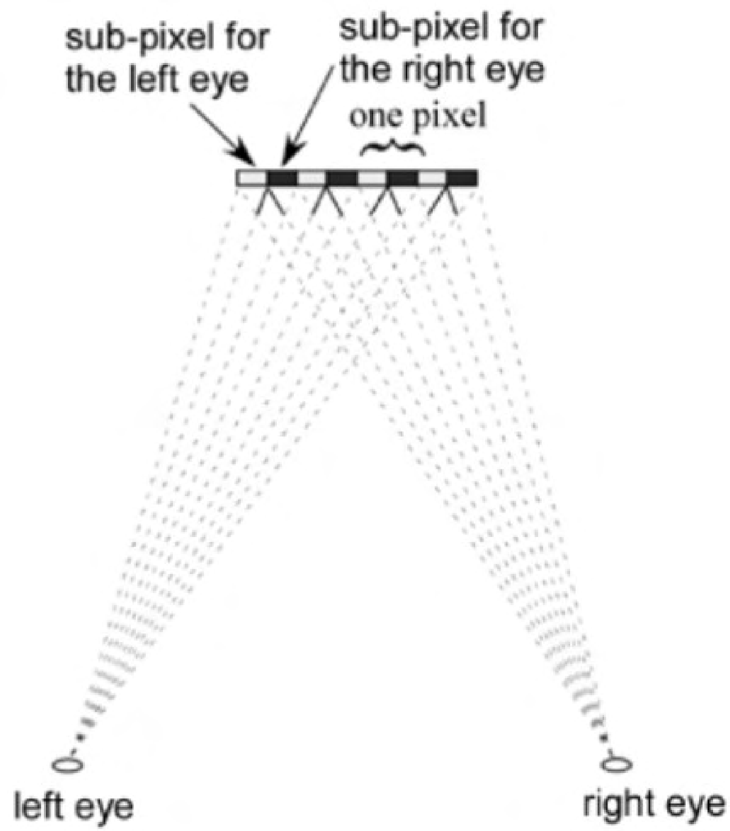


Figure 2 - an example of a stereoscopic parallax display using V-shaped barriers to reduce cross talk between left and right images.

- This article showcases a design for a parallax display that uses small V-shaped barriers to block the light from each image.
- The design has reduced cross talk by blocking more of the incorrect image from reaching each eye, such as blocking the left image from the right eye.
- This design may be very hard to manufacture though, because the angles of the V-shaped barriers need to change with the x-position on the screen, and the V-barriers would also need to be extremely small and precise.
- If the design is achieved though, it can greatly reduce cross talk when viewing from an off center viewing angle.

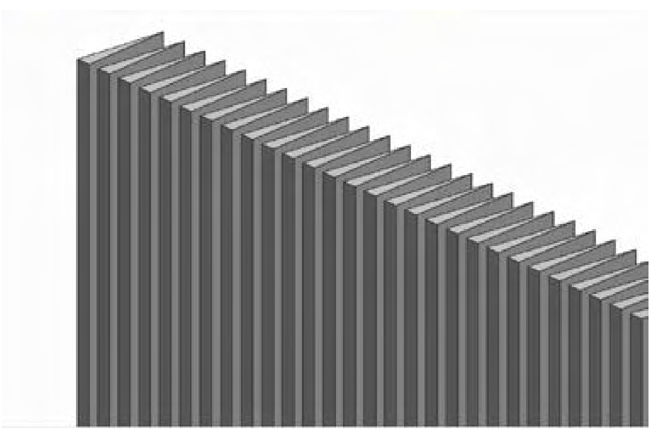


Figure 3 - 3D image of the V shaped barrier, these would need to be on the scale of pixels, making them very hard to precisely manufacture.

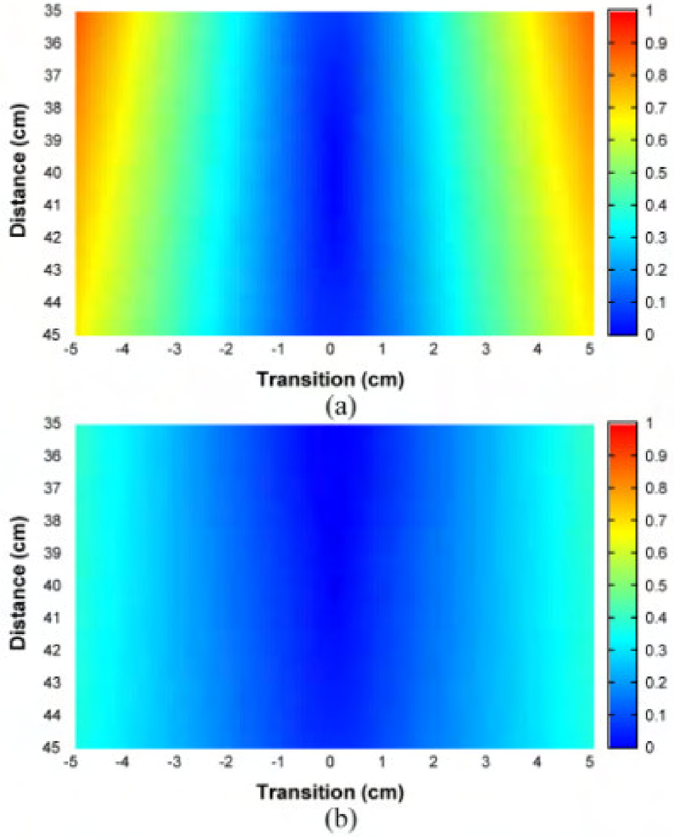


Figure 4 - Cross talk in relation to viewing angle and viewing distance. The normal parallax barrier is on top and the improved barrier is on bottom.

$$crosstalk_{pixel} = \frac{part\ of\ pixel\ seen\ by\ the\ incorrect\ eye}{pixel\ area}.$$

Figure 5 - Cross talk equation, will be useful for testing if we use this design option.

C. Lee, G. Seo, J. Lee, T. Han, and J. G. Park, "Auto-stereoscopic 3D displays with reduced crosstalk," Optics Express, vol. 19, no. 24, p. 24762, Nov. 2011, doi: 10.1364/oe.19.024762.

Conclusions/action items:

This display technology seems to advanced for the team to manufacture but the article did help me learn more about how parallax barriers work. The cross-talk equation will be useful for testing our design and comparing it to other designs available.

2021/10/15 - Using smartphone-delivered stereoscopic vision in microsurgery: a feasibility study

Nicholas Jacobson - Oct 20, 2021, 10:19 AM CDT

Title: Using smartphone-delivered stereoscopic vision in microsurgery: a feasibility study

Date: 2021/10/15

Content by: Nicholas Jacobson

Goals: View other research done on the feasibility of smartphone stereoscopic vision for microsurgery.

Content:

- The author performed a simulated cataract extraction operation using an iPhone screen in a VR headset.
- They used a stereo camera which provided accurate stereoscopic vision and depth.
- There was a delay of .354 seconds.
- Although there was a delay, the author was able to complete the surgery.
- The system was a stereo camera connected to a laptop, which then streamed the video to the smart phone over WiFi.
- The author came to the conclusion that it is a feasible option.
- The benefits of a setup like this include ability to stream surgeries across the globe for training as well as a lowered cost.

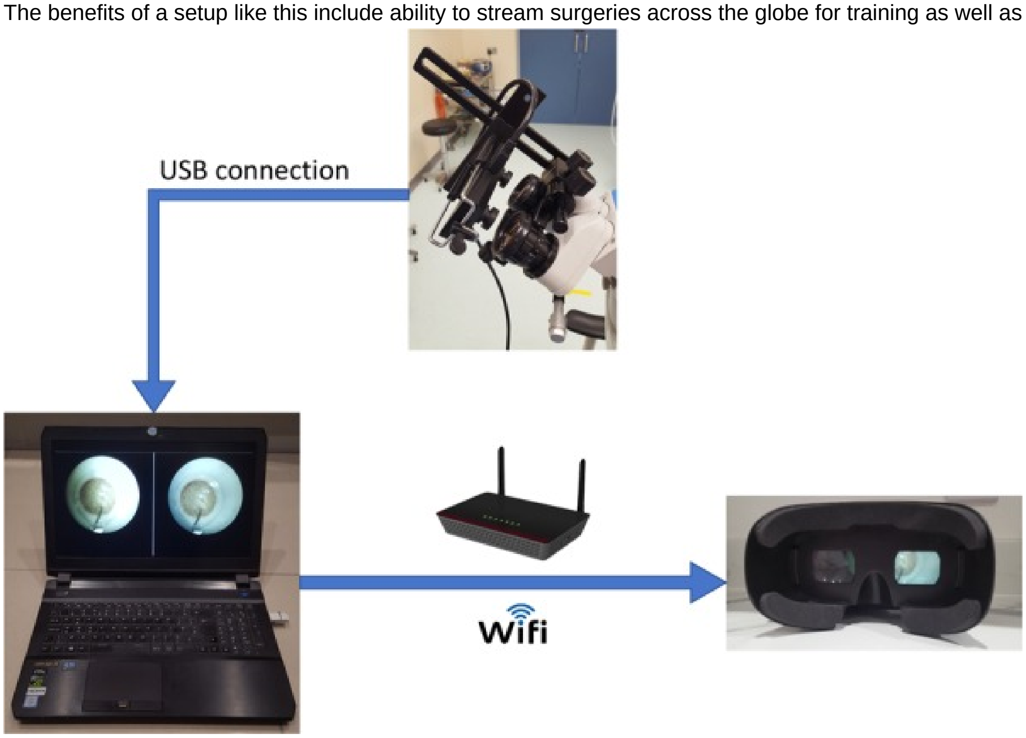


Figure 1 - The setup the author used was similar to one that our client's used when testing.

D. K. Ho, “Using smartphone-delivered stereoscopic vision in microsurgery: a feasibility study,” Eye, vol. 33, no. 6, pp. 953–956, Feb. 2019, doi: 10.1038/s41433-019-0356-8.

Conclusions/action items:

The author came to a lot of the same conclusions that our clients did when testing their design. It is feasible to use a VR headset and smartphone display to achieve stereoscopic vision, but the large delay needs to be fixed before it can be used clinically. Once our camera system is created, it can be tested with both VR headset and a parallax barrier display in order to find the best option to move forward with.

2021/09/25 - Orbeye Camera System

Nicholas Jacobson - Oct 20, 2021, 10:18 AM CDT

Title: Orbeye Camera System

Date: 2021/09/25

Content by: Nicholas Jacobson

Goals: Find another competing design and see what aspects we should try to replicate in our training tool.

Content:

- This microscope works by being a high resolution macro camera that can be freely positioned above the subject.
- The video feed is output to a stereoscopic display to achieve depth perception.
- 4K 3D imaging
- The free moving camera allows for more possible viewing angles of the surgical site.
- The large monitor allows for multiple surgeons to work together and share the same experience.
- The surgeon can also be seated in multiple different positions depending on preference or need.

"ORBEYE 4K 3D Digital Video Microscope | Olympus Medical Systems," www.olympus.co.uk. https://www.olympus.co.uk/medical/en/Products-and-solutions/Medical-specialities/Neurosurgery/ORBEYE.html [accessed Sept. 15, 2021].

Conclusions/action items:

This microscope is more similar to the design that the client requested, albeit at a much larger price. The stereoscopic display is something that the client requested we try to emulate in our design. With this information, our team can make a better informed decision about what needs to be included in our training tool.

2021/09/25 - Mitaka MM51 Microscope

Nicholas Jacobson - Oct 20, 2021, 10:18 AM CDT

Title: Mitaka MM51 Microscope

Date: 2021/09/25

Content by: Nicholas Jacobson

Goals: View the how a competing design currently works.

Content:

- Highest resolution surgical microscope available.
- 42x magnification.
- 4K monitor for displaying subject in operating room.
  - The monitor is not stereoscopic so not ideal to actually perform the surgery with.
- Surgeon needs to view subject through the two eye pieces, restrictive positioning compared to a large display.
- Allows for operation in sub 1mm environment.

“Highest Resolution Microsurgery Microscope | MM51,” Mitaka USA. https://mitakausa.com/mm51/ [accessed Sept. 25, 2021].

Conclusions/action items:

This is one competing design that was sent to us by the client. This microscope is similar to the one we practiced on when visiting the client. The client wanted us to move away from the restrictive eye piece design and try to display our training image on a stereoscopic display or VR headset. With this research the team will get a better idea of what is currently available for surgical microscopes.

2021/10/01 - Parallax Barrier Design

Nicholas Jacobson - Oct 20, 2021, 10:19 AM CDT

Title: Parallax Barrier Design

Date: 2021/10/01

Content by: Nicholas Jacobson

Goals: Design a parallax barrier that can be placed over a laptop screen in order to convert it into a stereoscopic display.

Content:

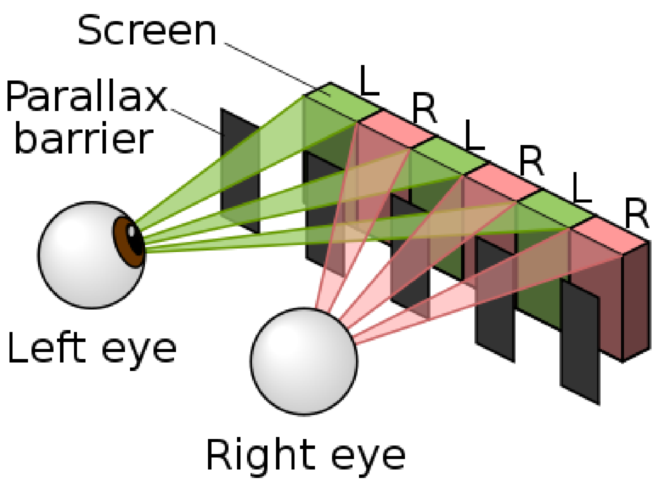


Figure 1 - Basic Parallax Barrier Design Concept

- The barrier will consist of a clear film with black bars printed on it.
- The bars will be the same width as the pixels on the laptop we plan on testing with.
- The design will be very low cost, as there are high DPI printers that can be used in the library. The only cost will be for the thin film.
- The film will be placed on top of the laptop screen (either hung from the top or rested on the bottom bezel) and will block the left image from hitting the right eye and vice versa.
- The laptop will display two videos interlaced between each other.
- The videos will be the same subject but viewed at different angles.
- The 2 videos will either come from two separate cameras or a single camera sensor split into 2 according to Haochen's design.

Conclusions/action items:

This design will be easy to test but may not be the most accurate according to earlier research. The parallax barrier can introduce a lot of cross talk between the left and right images so ways to circumvent that may be needed. This will be presented at the team meeting and further discussion will occur.

2021/11/17 - First Prototype Brainstorming

Nicholas Jacobson - Dec 15, 2021, 11:49 AM CST

Title: First prototype brainstorming

Date: 2021/11/17

Content by: Nicholas Jacobson

Present: Nicholas Jacobson

Goals: Document ideas for how we can fabricate our first prototype and propose them to the team.

Content:

All designs will use the mirror dimensions calculated prior

Mirrors Mounted on Magnets on top of a metal plate

- This design would consist of mirrors that are mounted upright on top of magnets that are stuck to a metal plate.
- This would allow for sturdiness in the mirrors with the ability to move them around on the fly.
- An issue with this design is that the magnets I purchased are too large and would collide with another if they weren't made smaller.
- Making sure the mirrors are perfectly perpendicular when mounting them would also be a challenge

3D printed housing

- A 3D printed housing could be made with slits cut out exactly for the mirrors.
- This would allow the mirrors to be placed in exactly where we calculated them to be
- An issue with this design is that we would have to wait for the print to be made, cutting into our testing time.
- There is also no flexibility in this design which means no adjusting can be done if the calculations do not produce a good result

Mirrors taped to cardboard base

- The mirrors could be taped upright to a cardboard base, although this would introduce many inaccuracies
- I was thinking a small stand could be made for each mirror, the mirror would mount to the stand and be held perpendicular to the cardboard.

Conclusions/action items: These are a few ideas I had for building the first prototype. This still doesn't answer the question of how we will mount the device to a phone screen, so that needs to be figured out still. These will be presented to the team when we meet for the first fabrication session.

2021/11/19 - Testing First Prototype

Nicholas Jacobson - Dec 15, 2021, 12:30 PM CST

Title: Testing First Prototype

Date: 2021/11/19

Content by: Nicholas Jacobson

Present: Team

Goals: Get a baseline from the first prototype so we know what to improve upon.

Content:

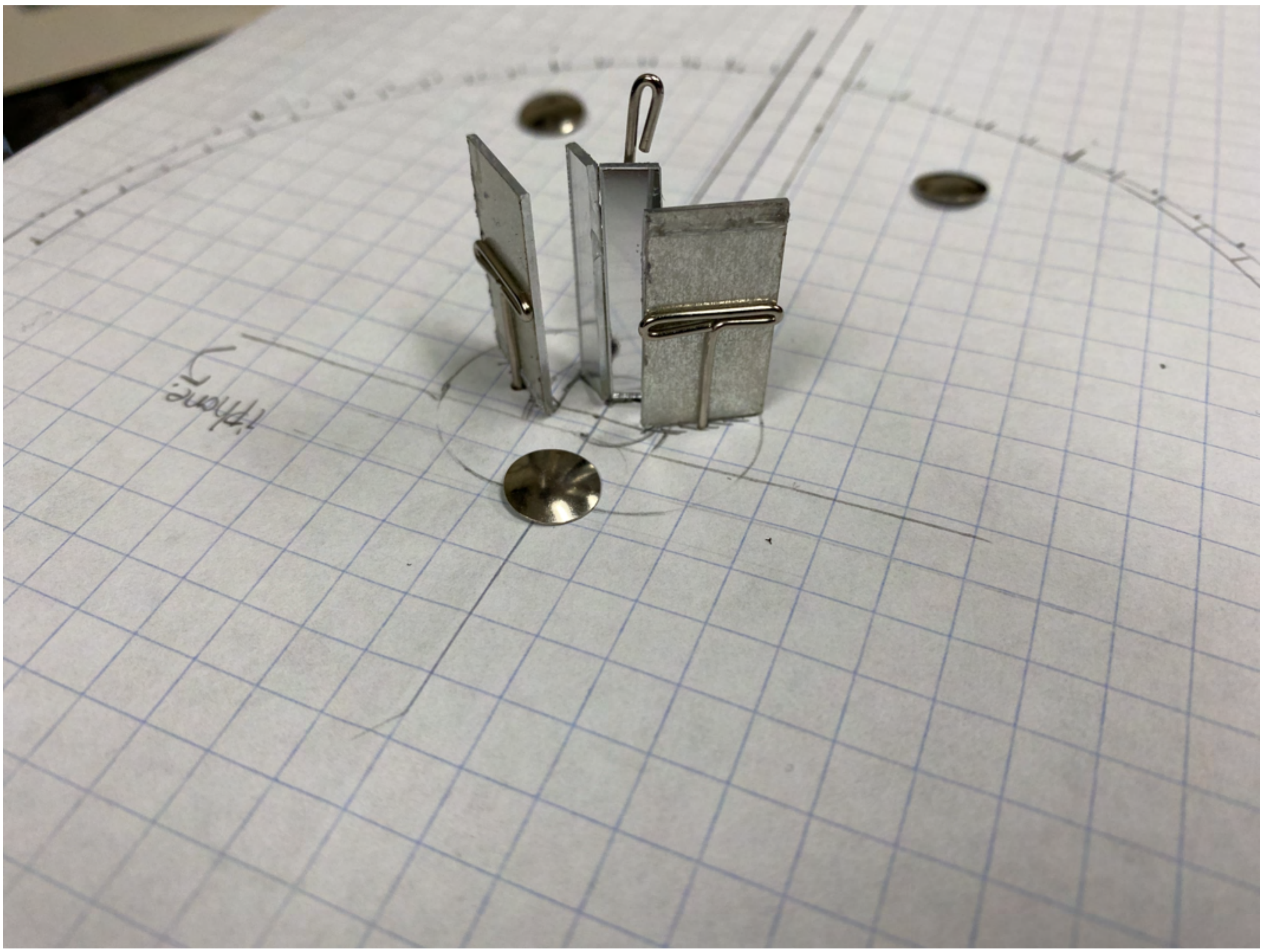


Figure 1: Prototype design using the mirrors' adhesive back to stick to pins that are stuck in foam. The iPhone rests on its side with the sensor placed right in front of the two inner mirrors. An issue we had was keeping the iPhone in place and making sure it didn't shift the mirrors at all.

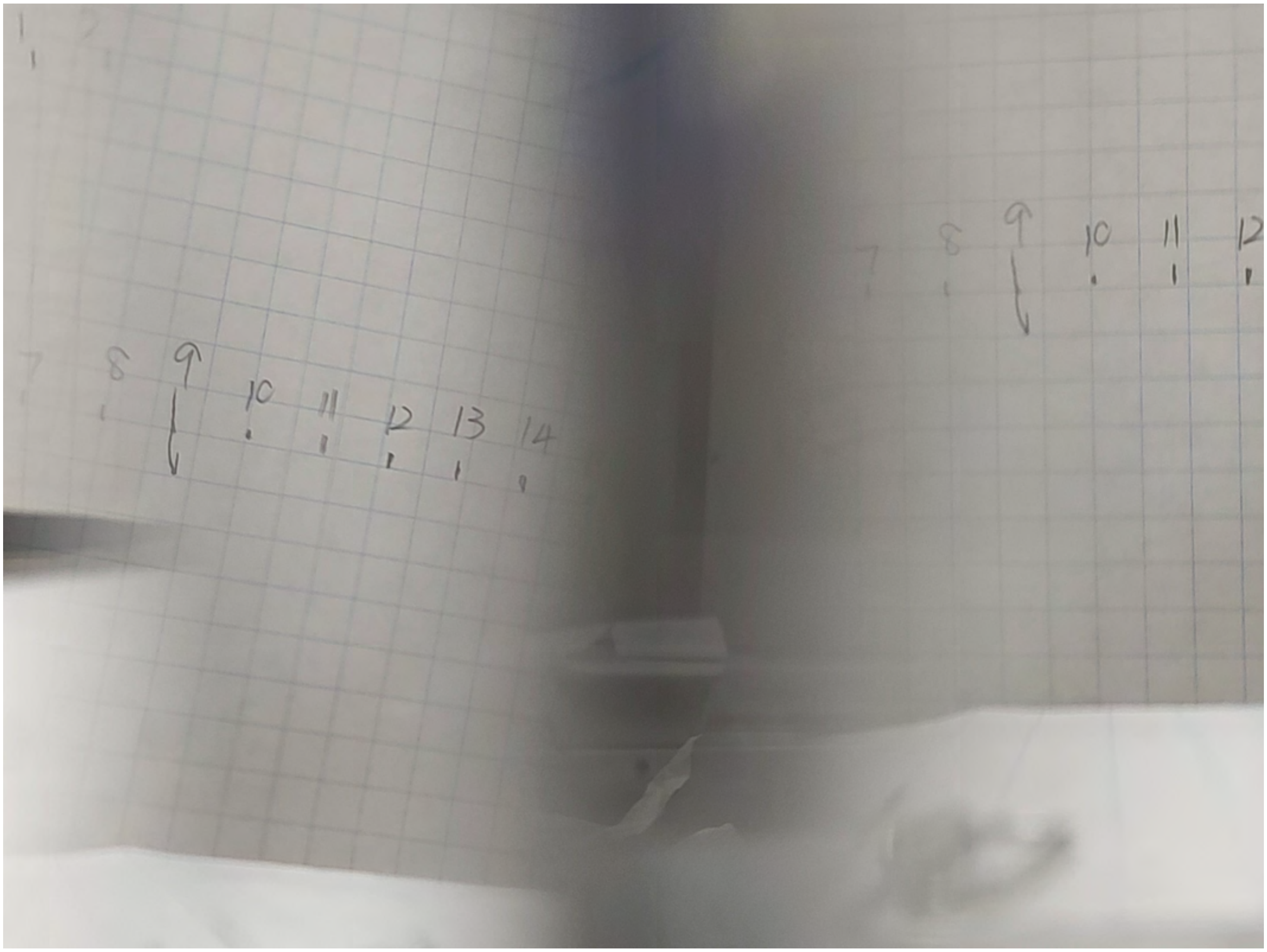


Figure 2: A view through prototype 1. The numbers were used to make sure the two images matched each other as closely as possible.

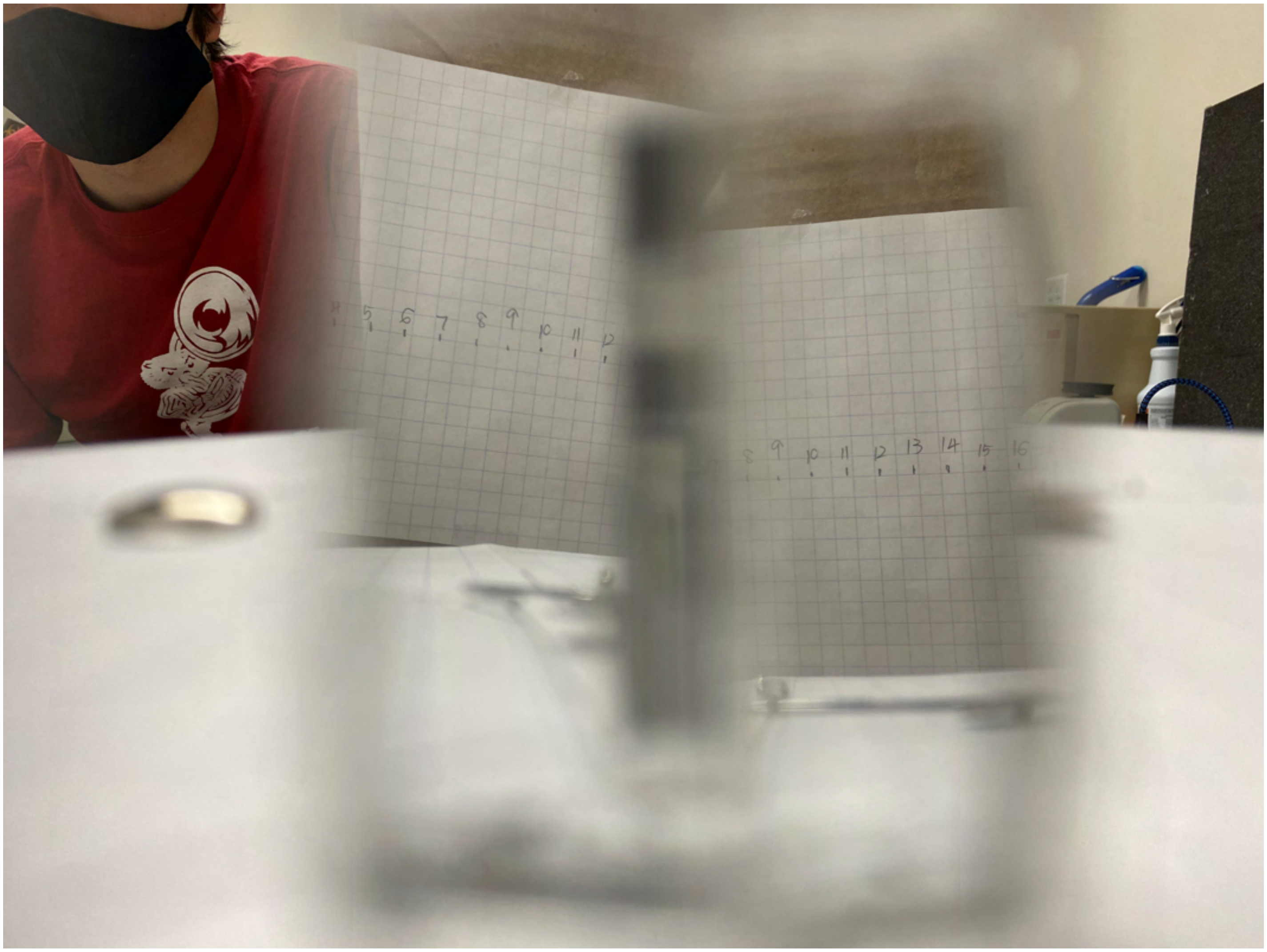


Figure 3: Another view from the camera sensor of the iPhone. This shows that the camera is able to focus well on the subject, but it is very difficult to get the mirrors to exactly face the subject.

After testing the first prototype, we know that we need to refine the design in order to make the mirrors more sturdy. This design with the mirrors stuck to the pins was very finicky, making it very hard to get the mirrors to produce similar images. In figure 2, it can be seen that we were trying to get the mirrors to focus on the nine in the middle, but any slight deviation in the mirrors made the image shift or rotate.

The design does end up producing two images at the iPhone sensor which is a good sign, however we will need to refine this design and think of a way to make the mirrors more sturdy.

Conclusions/action items: A lot of work needs to be done to improve the stability and accuracy of the mirrors, but this is a good start for the team as we were able to show that the mirrors do produce two views of the same subject when they are lined up accurately.

2021/12/06 - Testing Google Cardboard with our Prototype

Nicholas Jacobson - Dec 15, 2021, 11:26 AM CST

Title: Testing Google Cardboard with our Prototype

Date: 2021/12/06

Content by: Nicholas Jacobson

Present: Team

Goals: Test to see if our device provides adequate stereoscopic vision as is.

Content:

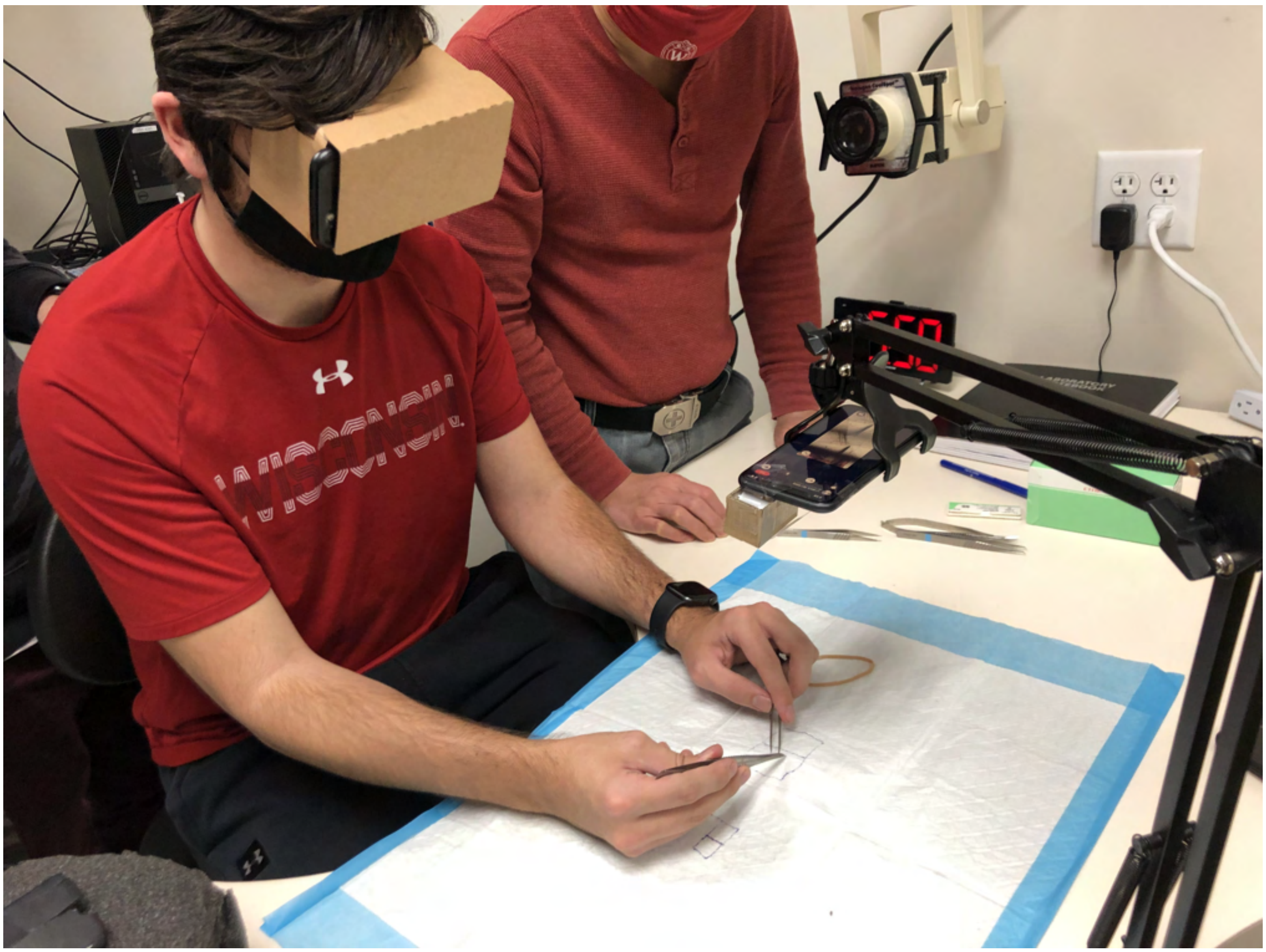


Figure 1: Trying to replicate the previous test where sutures were moved from one area to another as fast as possible.

I tested the Google Cardboard with our prototype. In the image, the phone with our prototype is mounted to an iPhone stand.The video feed from the prototype is being Facetimed to the VR headset phone.

Figure 2: The view seen from inside of the VR headset. The 2 lenses in the headset focus the eyes on each of the images, and the brain combines them in order to achieve depth perception.

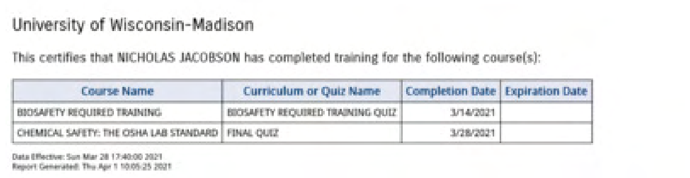
Testing Notes:

- Because the two images in the VR headset were not in the same place with respect to the lenses, the VR headset produced a double image instead of a single one. This could be fixed with cropping and rotating of the received video, making sure that the image coming through both lenses is nearly identical.
- It was possible to see the sutures but the headset was blurry, they were hard to make out from the white background.
- The iPhone camera would auto focus onto the forceps instead of the working area, this could be fixed by using manual focus instead of auto focus.
- Wearing the VR headset was also disorienting, a more natural way the view the subject should be devised in the future.
- The headset did have a good amount of zoom and there was a slight depth perception effect. The latency from Facetime wasn't huge but it was enough to be noticeable when using the headset.

Conclusions/action items: Although using the headset with our prototype did not meet all of our expectations, it gives us a good place to build from in the future. There are a lot of things that we can improve about the prototype in the coming semester.

04/01/2021 - Biosafety and Chemical Safety Certification

Nicholas Jacobson - Dec 15, 2021, 12:38 PM CST



University of Wisconsin-Madison

This certifies that NICHOLAS JACOBSON has completed training for the following course(s):

Course Name	Curriculum or Quiz Name	Completion Date	Expiration Date
BIOSAFETY REQUIRED TRAINING	BIOSAFETY REQUIRED TRAINING QUIZ	3/14/2021	
CHEMICAL SAFETY: THE OSHA LAB STANDARD	FINAL QUIZ	3/28/2021	

Data Effective: Sun Mar 28 17:40:00 2021
Report Generated: Thu Apr 1 10:05:25 2021

Screenshot_2021-04-01_Certificate_of_Completion_for_NICHOLAS_JACOBSON.png(44.9 KB) - download

2021/09/23 - The Surgical Suture

HAOCHEN WANG - Sep 23, 2021, 8:17 PM CDT

Title: The Surgical Suture

Date: 09/23/2021

Content by: Haochen Wang

Present: N/A

Goals: To get more information on the specification (and thus the resolution) of sutures

Permanent link/reference:

B. M. A. A; "The surgical suture," *Aesthetic surgery journal*, Apr-2019. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/30869751/. [Accessed: 24-Sep-2021].

Summary:
This article introduces the suture used in surgeries. The authors focuses on the biomaterial and material mechanics of the sutures currently available in the market.

Notes:

Since the supplement mainly focuses on the material perspective of the sutures, only specifications of sutures used in plastic surgery are noted here.

3-0 Three Zero (Metric gauge - 2) Diameter 0.200 - 0.249 mm

6-0 Six Zero (Metric gauge - 0.7) Diameter 0.070 - 0.099 mm

Conclusions/action items:

Apply this information to determine resolution, magnification and contrast of video streaming as part of the PDS

HAOCHEN WANG - Sep 23, 2021, 8:18 PM CDT

Supplement

The Surgical Suture

Miriam Byrne, MD, FRCS (Plast); and Ali Aly, MD, FACS

OXFORD UNIVERSITY PRESS

Abstract

The word suture is derived from the Latin sutura, "a seam." Materials including linen, cotton, horsehair, animal tendons and intestines, and wire from precious metals have been used to approximate wounds and act as ligatures. Many adaptations over time have led to the highly sophisticated products we use in our practice today.

Suture Characteristics

The_Surgical_Suture.pdf(168.2 KB) - download

2021/09/23 - Operational Environment

HAOCHEN WANG - Sep 23, 2021, 9:47 PM CDT

Title: DR. SAM POORE AND TEAM FEATURED ON BTN LIVEBIG WISCONSIN

Date: 09/23/2021

Content by: Haochen Wang

Present: N/A

Goals: To gain knowledge on the working environment of the intended users

Permanent link/reference:

“Dr. Sam POORE and team featured ON BTN LiveBIG Wisconsin,” *Department of Surgery*, 13-Jul-2020. [Online]. Available: https://www.surgery.wisc.edu/2020/07/13/dr-sam-poore-and-team-featured-on-btn-livebig-wisconsin/. [Accessed: 24-Sep-2021].

Summary:

The website and the video demonstrates the working environment of the clients, who developed a method using chicken thigh and blue food dye plumping system to mimic arterial and venous conditions. Observe that for the trainees, it is possible to splash the tissue or organic liquid onto the device, while equipment may damage the lenses (if there is any attached to the smartphone). So these are risks that shall be considered in final deliverables.

Conclusions/action items:

Refer the website to the other team members and address the risks

2021/10/11 - Depth Resolution Minimal Requirement (Chicken breast thickness)

HAOCHEN WANG - Oct 11, 2021, 12:33 PM CDT

Title: Effect of multiple freeze–thaw cycles on the quality of Chicken Breast Meat

Date: 10/11/2021

Content by: Haochen Wang

Present: N/A

Goals: To gain knowledge on the human depth from chicken breast (model used by the clients)

Permanent link/reference:

S. Ali, W. Zhang, N. Rajput, M. A. Khan, C.-bao Li, and G.-hong Zhou, “Effect of multiple freeze–thaw cycles on the quality of Chicken Breast Meat,” *Food Chemistry*, vol. 173, pp. 808–814, Sep. 2015.

Summary:

The paper provides a typical thickness of chicken breast, which will be the dZ_h value (= 2.5 cm) used in the following equation:

$$dZ_h = \frac{Z^2 \Delta T}{I} \tag{1}$$

Conclusions/action items:

Refer the paper for calculation on the parameters of the design

2021/09/03-Presentation Notes-A Quick Look at Two Types of MR

HAOCHEN WANG - Sep 13, 2021, 7:21 PM CDT

Title: A Quick Look at Two Types of MR

Date: 09/03/2021

Presenter: Mark A. Griswold

Affiliation: Case Western Reserve University - University Hospitals

Content by: Haochen Wang

Present: Haochen Wang

Goals: To learn how mixed reality help with surgery and anatomical instructions

Content:

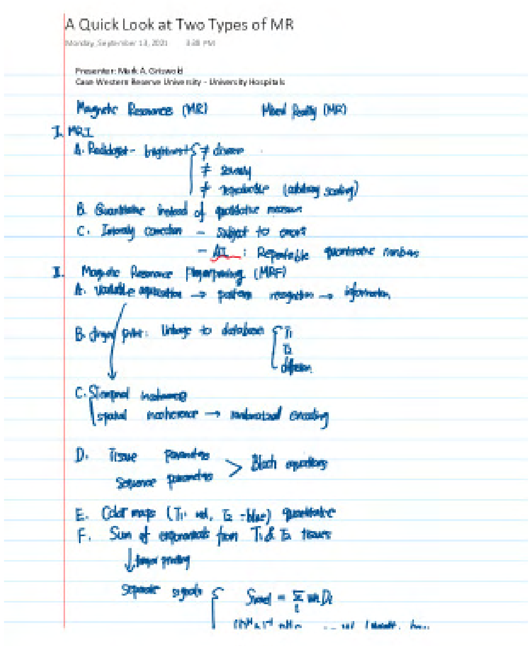
Dr. Griswold introduced magnetic resonance fingerprint (MRF), an enhanced MRI technology that achieves better resolution and diagnostic power, and mixed reality with Hololens (Microsoft), which provided virtual, 3-D learning for anatomy at Case.

See attached document for full presentation notes.

Conclusions/action items:

1. Investigate potential of using AI to process multi-depths frames
2. Seek for potential in developing hardware illustrating processed frames from previous design teams
3. Search, or ask Dr. Griswold if there are more questions to be asked as a team, how 3D demonstration is achieved in hololens for a dynamic MRI imaging (software? hardware level at the MRI machine? or via Hololens?)

HAOCHEN WANG - Sep 13, 2021, 7:22 PM CDT



Wang_Haochen-BME_300-Presentation_Notes-A_Quick_Look_at_Two_Types_of_MR.pdf(2.7 MB) - download

2021/09/03- BME 402 Preliminary Report from Previous Design Team

HAOCHEN WANG - Oct 20, 2021, 3:11 AM CDT

Title: BME 402 Preliminary Report

Date: 09/03/2021

Content by: Haochen Wang

Present: N/A

Goals: To understand progress and achievements from the previous design team

Summary:
The authors developed an algorithm via MATLAB that processes video recorded from iPhone by duplicating, rotating, filtering and chopping. The output video will be then streamline to a monitor. The algorithm was proved working, but with significant delay in processing.

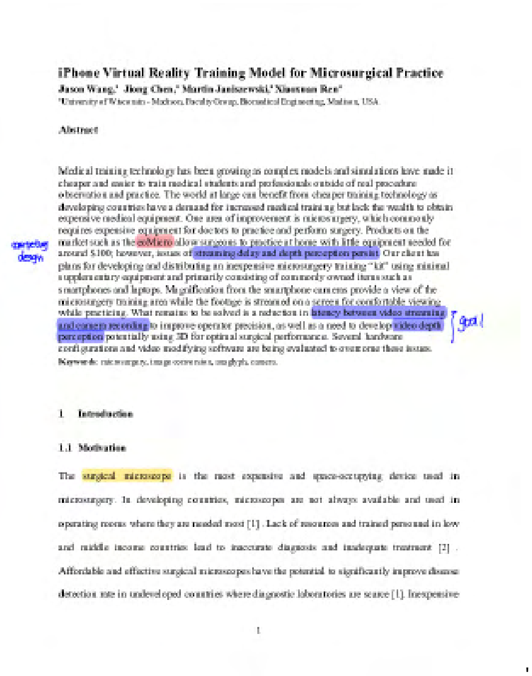
Notes:

1. Potential delay arises from angling two 2D images to create an illusion of depth perception
2. Legacy in streaming and low resolution are common issues with VR glasses
3. The codes are abstracted into a flow chart, and a improved design is proposed as the efficient algorithm design
4. The filters are anaglyphs, which means the output video would require bipolar lenses to view and get the depth perception
5. Rotation and separation is arbitrary
6. The field of view is sacrificed due to chopping

Conclusions/action items:

- Construct a potential solution from the notes.
- Discuss findings with the team.

HAOCHEN WANG - Oct 20, 2021, 3:11 AM CDT



iPhone Virtual Reality Training Model for Microsurgical Practice

Jason Wang,[1] Jiong Chen,[1] Martin Janiszewski,[1] Xiaoxuan Ren[1]
[1]University of Wisconsin - Madison, Faculty Group, Biomedical Engineering, Madison, USA

Abstract

Medical training technology has been growing as complex models and simulations have made it cheaper and easier to train medical students and professionals outside of real procedure observation and practice. The world at large can benefit from cheaper training technology as developing countries have a demand for increased medical training but lack the wealth to obtain expensive medical equipment. One area of improvement is microsurgery, which commonly requires expensive equipment for doctors to practice and perform surgery. Products on the market such as the ezMicro allow surgeons to practice at home with little equipment needed for around $100; however, issues of streaming delay and depth perception persist. Our client has plans for developing and distributing an inexpensive microsurgery training "kit" using minimal supplementary equipment and primarily consisting of commonly owned items such as smartphones and laptops. Magnification from the smartphone camera provide a view of the microsurgery training area while the footage is streamed on a screen for comfortable viewing while practicing. What remains to be solved is a reduction in latency between video streaming and camera recording to improve operator precision, as well as a need to develop video depth perception potentially using 3D for optimal surgical performance. Several hardware configurations and video modifying software are being evaluated to overcome these issues.

Keywords: microsurgery, image conversion, anaglyph, camera.

1 Introduction

1.1 Motivation

The surgical microscope is the most expensive and space-occupying device used in microsurgery. In developing countries, microscopes are not always available and used in operating rooms where they are needed most [1]. Lack of resources and trained personnel in low and middle income countries lead to inaccurate diagnosis and inadequate treatment [2]. Affordable and effective surgical microscopes have the potential to significantly improve disease detection rate in undeveloped countries where diagnostic laboratories are scarce [1]. Inexpensive

1

BME_402_Preliminary_Report.pdf(2.1 MB) - download

2021/09/30 - Complementary Multi-Bandpass Filters

HAOCHEN WANG - Oct 20, 2021, 2:15 AM CDT

Title: New technique of three-dimensional imaging through a 3-mm single lens camera

Date: 09/30/2021

Content by: Haochen Wang

Present: N/A

Goals: To get more information on a potential solution to the design problem

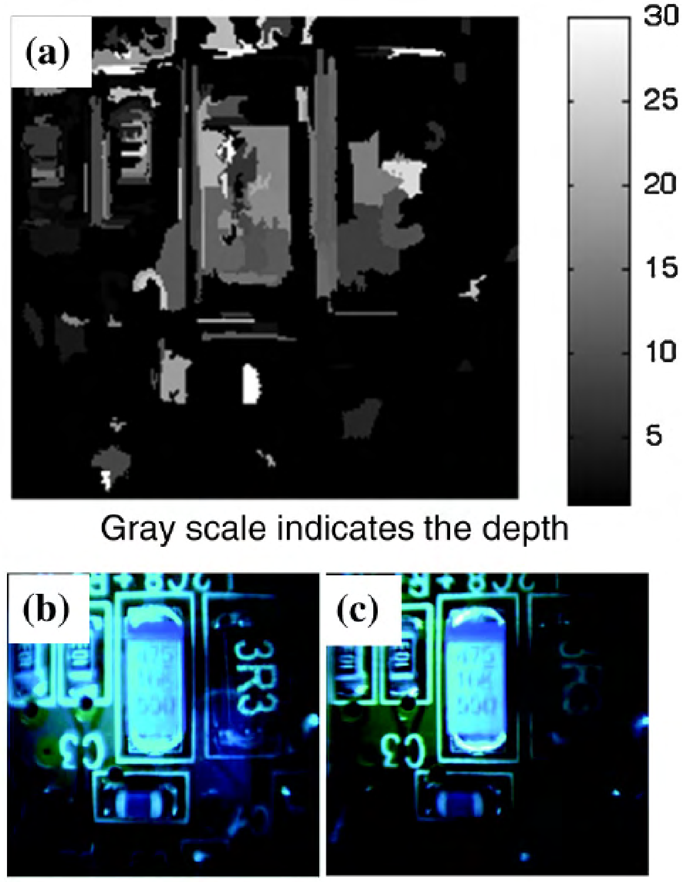
Permanent link/reference:

S. Y. Bae, R. J. Korniski, H. M. Manohara, A. Ream, and H. K. S. M.D., "New technique of three-dimensional imaging through a 3-mm single lens camera," *Opt. Eng*. vol. 51, no. 2, pp. 1–8, 2012, doi: 10.1117/1.OE.51.2.021106.

Summary:
This article introduces a design on creating 3D imagery from single capture, using multiband pass filter for wavelengths to produce differentiated view from two perspectives.

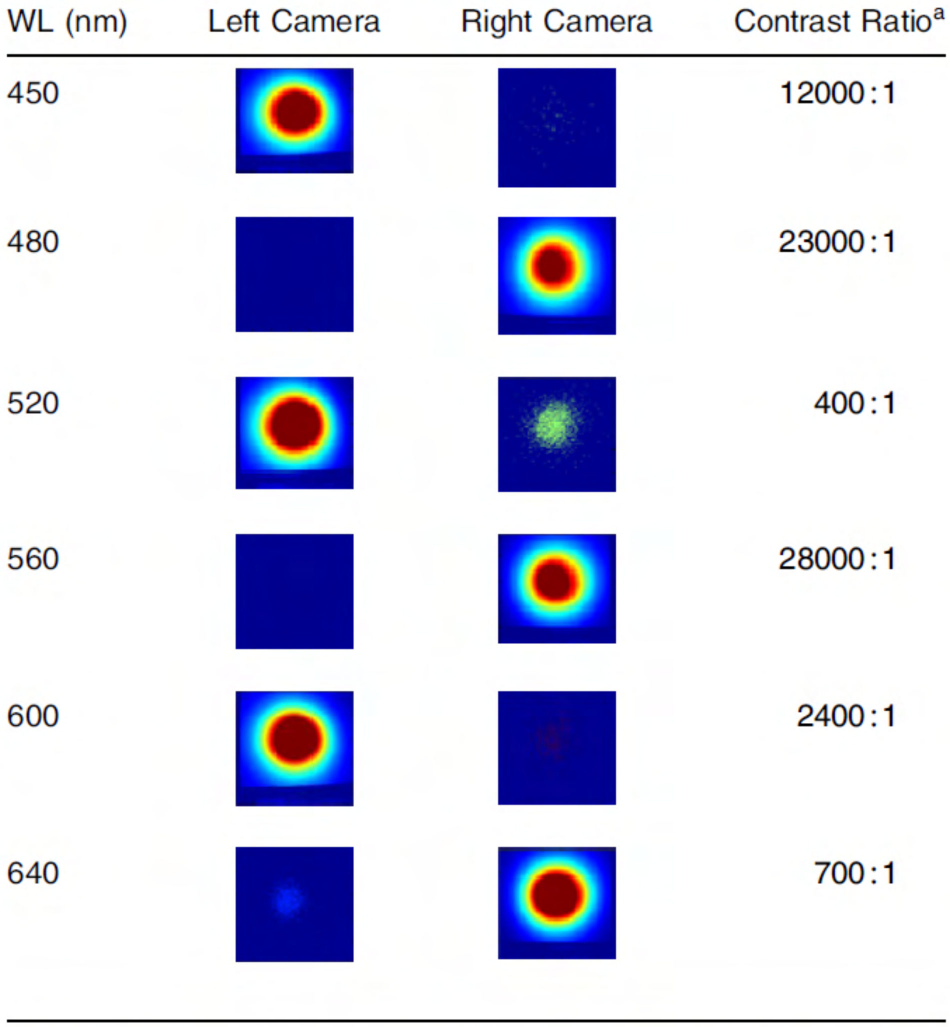
Notes:

1. The design contains a single-lens, split aperture approach to generate stereo images
2. Depth resolution is defined by the following equation
    1. $$\mathrm{dZ}_c = \frac{Z^2 \cdot \Delta T}{M \cdot b},$$
    2. z is the working distance
    3. delta T is the stereo acuity
    4. M is magnification
    5. b is baseline distance
3. The design contains two complementary multi-bandpass filter (CMBF) coupled with spectral illumination bands (SIBs)
    1. Light with wavelength selected by SIBs will be shone on the object
    2. Light reflected by the object passes through only one of the filters
    3. The wavelength of the emitted light changes
    4. The new wavelength passes only through the other filter
    5. Repeat 1-4 for a full visible light profile
    6. Resulting in two images with complementary color profile taken at slightly different angle from the object
    7. The brain then can merge the images together and compensate for the color difference, thus depth perception is formed
    8. [Note] The resulting image is similar to the expected result from splitting lens design, which proves the feasibility of the design
    9. [Note] The resulting image can maintain it's original color profile, which means that CMBF design may be considered as an enhanced version of the splitting lens design (see figure below)



1. **Fig. 8** (a) A 2D projection depth map of a stereo image captured by the dual-aperture 3-D camera. The scale on the right shows the depth. The darker the gray scale, the farther the point from the camera: (b) left image, (c) right image.

10. However, color pollution can occur, and this may affect the image quality



WL (nm)	Left Camera	Right Camera	Contrast Ratio[a]
450			12000 : 1
480			23000 : 1
520			400 : 1
560			28000 : 1
600			2400 : 1
640			700 : 1

1. [a]The ratios are calculated by dividing the greatest to least average pixel value of the center regions.
2. Observe that for 520 nm, the right camera is stimulated, which is expected to be muted. Same effect is observed at 640 nm for the left camera, which demonstrate fade signal.

Conclusions/action items:

- Construct a potential solution from the notes.
- Discuss findings with the team.
- Search for the terms highlighted in the paper.
- Use the equation above to evaluate the depth resolution of the final design

HAOCHEN WANG - Oct 01, 2021, 12:21 PM CDT


Optical Engineering

New technique of three-dimensional imaging through a 3-mm single lens camera

Sam Y. Bae
Ron Korniski
Allen Ream
Hrayr Shahinian
Harish M. Manohara

SPIE

New_technique_of_three-dimensional_imaging_through_a_3-mm_single_lens_camera.pdf(2.3 MB) - download

2021/09/30 - Olympus Orbeye

HAOCHEN WANG - Oct 20, 2021, 2:50 AM CDT

Title: Olympus Orbeye

Date: 09/30/2021

Content by: Haochen Wang

Present: N/A

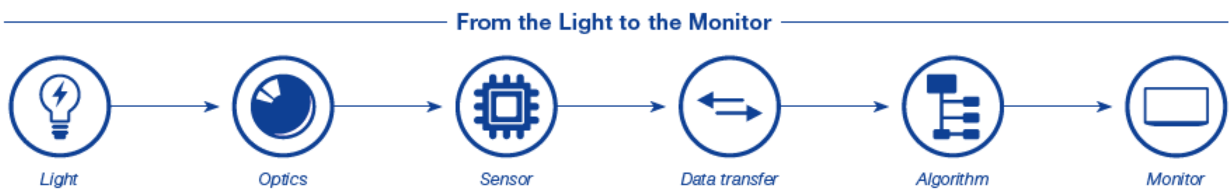
Goals: To get more knowledge on the existing device used by the clients

Permanent link/reference:

Olympus, “Revolutionize your surgical microscopy - Olympus,” *Olympus - Orbeye*. [Online]. Available: https://www.olympus-europa.com/medical/rmt/media/en/Content/Content-MSD/Images/SRP-Pages/SRP-ORBEYE/ORBEYE_concept_brochure_53297.pdf. [Accessed: 20-Oct-2021].

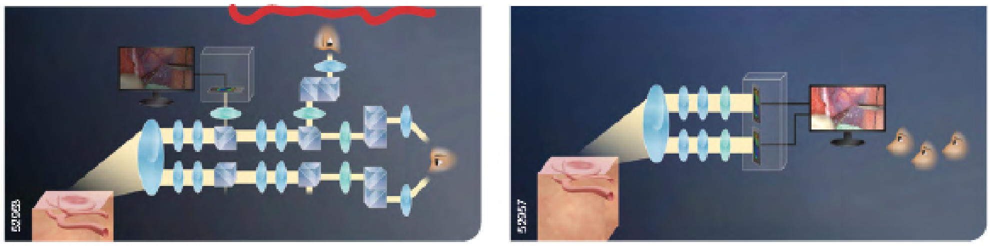
Summary:
The brochure introduces a surgical exoscope currently used by the clients.

Notes:

1. 

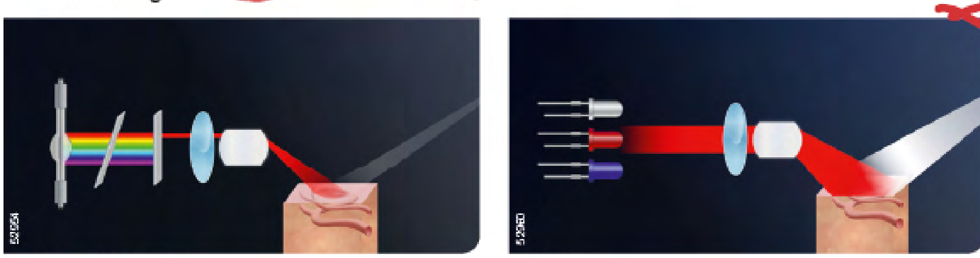
    1. Observe that the process adopted by Orbeye provides insight in methods to intervene during video streaming
    2. Light may be harmful for the user, thus is less likely to be changed
    3. Optics is the best option among all steps to intervene, since this not only reduces the time lag by directly capturing video with depth information, optics design is easier to design and fabricate.
    4. Sensor is a higher level hardware design. This is a less feasible level since not all group members have adequate knowledge.
    5. Algorithm is adopted by the previous design team, there is room for improvement, but the efficiency is uncertain
    6. Monitor like Nintendo 3DS can illustrate 3D effects with naked eyes, which may be advantageous over the other steps as no extra equipment is needed. However, this still relies on sensor and microelectronics, which may be difficult for a 200/300 level course.
2. The device contains two sets of lens to produce a depth perception, and can illuminate light with different wavelengths to make certain tissue appear more obvious
    1. The parallel lens design may be used in a design at optics level

1. Light passes through fewer optical lenses compared to an ocular-based microscope.



Standard surgical microscope *ORBEYE*

2. The use of dedicated blue and red LEDs, rather than relying on filters removing light wavelengths from white light.



Standard surgical microscope *ORBEYE*

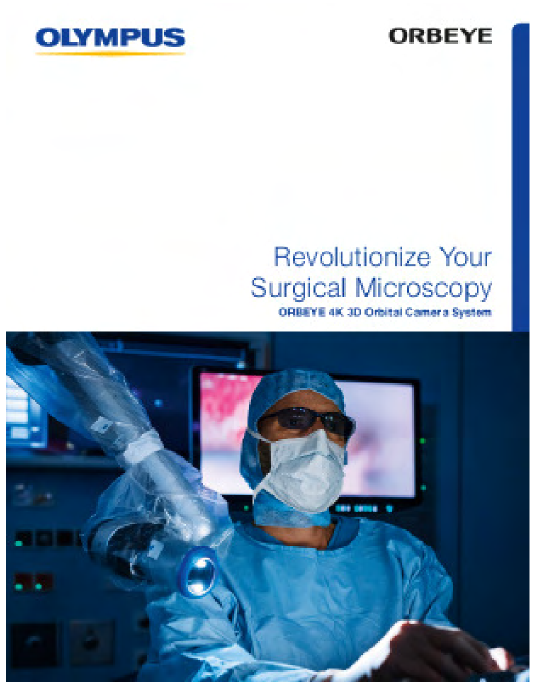
3. The Exmor R CMOS image sensor made by SONY has the light-receiving surface located above the wiring layer. Therefore, most of the available light reaches the sensor.

2. *Standard surgical microscope* *ORBEYE*

Conclusions/action items:

- Construct a potential solution from the notes.
- Discuss findings with the team.

HAOCHEN WANG - Oct 20, 2021, 2:39 AM CDT



ORBEYE_concept_brochure_53297.pdf(7.8 MB) - download

2021/10/19 - Depth Perception with a Single Camera

HAOCHEN WANG - Oct 20, 2021, 3:02 AM CDT

Title: Depth Perception with a Single Camera

Date: 10/19/2021

Content by: Haochen Wang

Present: N/A

Goals: To get more knowledge on a potential update on the splitting lens design

Permanent link/reference:

J. Seal, D. Bailey, and G. Sen Gupta, "Depth perception with a single camera," 2005.

Summary:

The authors introduce a novel version of the splitting lens design. Instead of prisms and converging lenses, the authors develop mathematical relationship for positioning of two pairs of mirrors. Light emitted by the object will reach the first pair (outer pair) of mirrors, which will then be reflected to the second pair (inner pair). The light will be converged at a virtual pinhole and being sent through the camera lens, which will produce an image with depth information as if two virtual cameras at an angle recording the same object.

Notes:

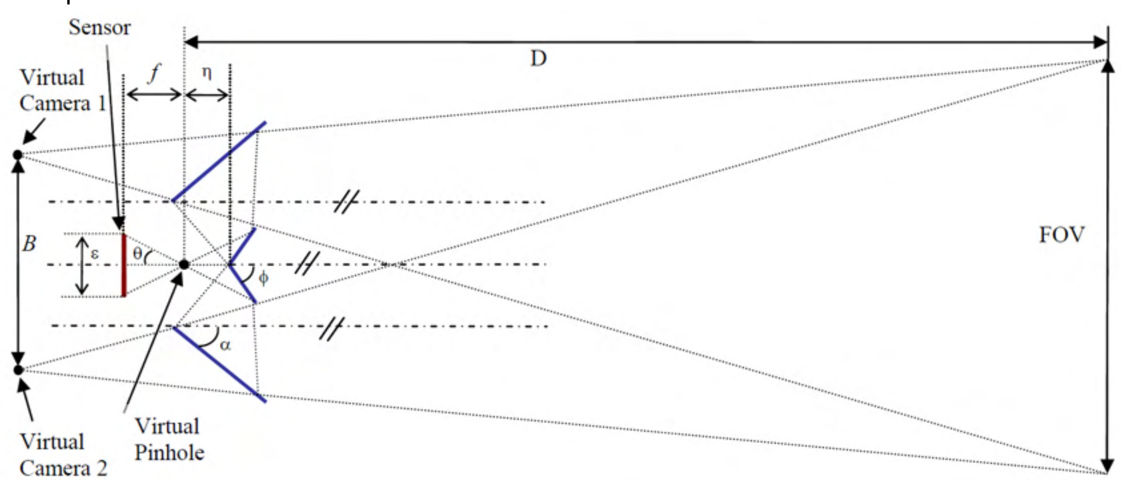
1. Design set up
    1. 

       Figure 1:the catadioptric system showing positions of mirrors, pinhole and definitions of important variables.
2. Parameters
    - ε = The sensor size
    - f = focal length of the lens
    - θ = The angle formed by the outside ray from the sensor that passes through the pinhole
    - η = the distance of the pinhole from the vertex of the inside mirrors
    - φ = the inside mirror angle
    - α = outside mirror angle
    - D = working distance
    - FOV = field of view at working distance
    - B = baseline or the distance between the pinholes in the virtual cameras

- λ = the width of one pixel on the sensor

3. Equations derived from the provided mathematical model

   See attached word document

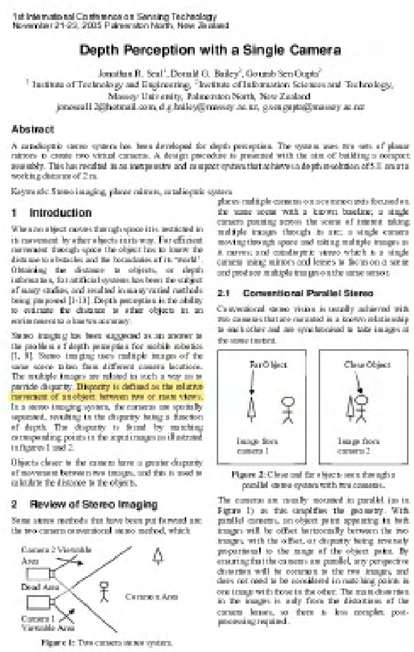
Conclusions/action items:

- Construct a potential solution from the notes.
- Discuss findings with the team.

HAOCHEN WANG - Oct 20, 2021, 3:02 AM CDT

Equations.docx(16.2 KB) - download

HAOCHEN WANG - Oct 20, 2021, 3:02 AM CDT



Depth_Perception_with_a_Single_Camera.pdf(638.2 KB) - download

2021/10/20-Website Screenshot-Specifications of iPhone 8 sensor

HAOCHEN WANG - Oct 20, 2021, 1:59 AM CDT

Title: Specifications of iPhone 8 Camera

Date: 10/20/2021

Content by: Haochen Wang

Present: N/A

Goals: To gain information on the lambda value from the mathematical model developed by Seal's team

Reference: "IPhone 8 sensor size," *iPhone 8 sensor size: iOS Talk Forum: Digital Photography Review*, 22-Sep-2017. [Online]. Available: https://www.dpreview.com/forums/post/60151245. [Accessed: 20-Oct-2021].

Content:

- The pixel size of the camera sensor of iPhone 8 is 1.22 micron by 1.22 microns
- The sensor is 4032 pixel (epsilon) by 3024 pixel
- The actual focal length (f) is 3.99 mm

Conclusions/action items:

1. Note that these values are not explicitly provided by Apple company, thus the only realize source available is this forum
2. The confidence on the values are high, since multiple technicians confirmed the values in later posts
3. The actual video quality shall be determined during test, so the exact values may not be influential, yet they provide insights on the design during the preliminary phase of the project

HAOCHEN WANG - Oct 20, 2021, 1:59 AM CDT

iPhone_8_sensor_size.mhtml(2 MB) - download

2021/10/01-Splitting Lens Design

HAOCHEN WANG - Oct 01, 2021, 11:56 AM CDT

Title: Splitting Lens Design

Date: 10/01/2021

Content by: Haochen Wang

Present: N/A

Goals: To introduce a splitting lens design

Content:

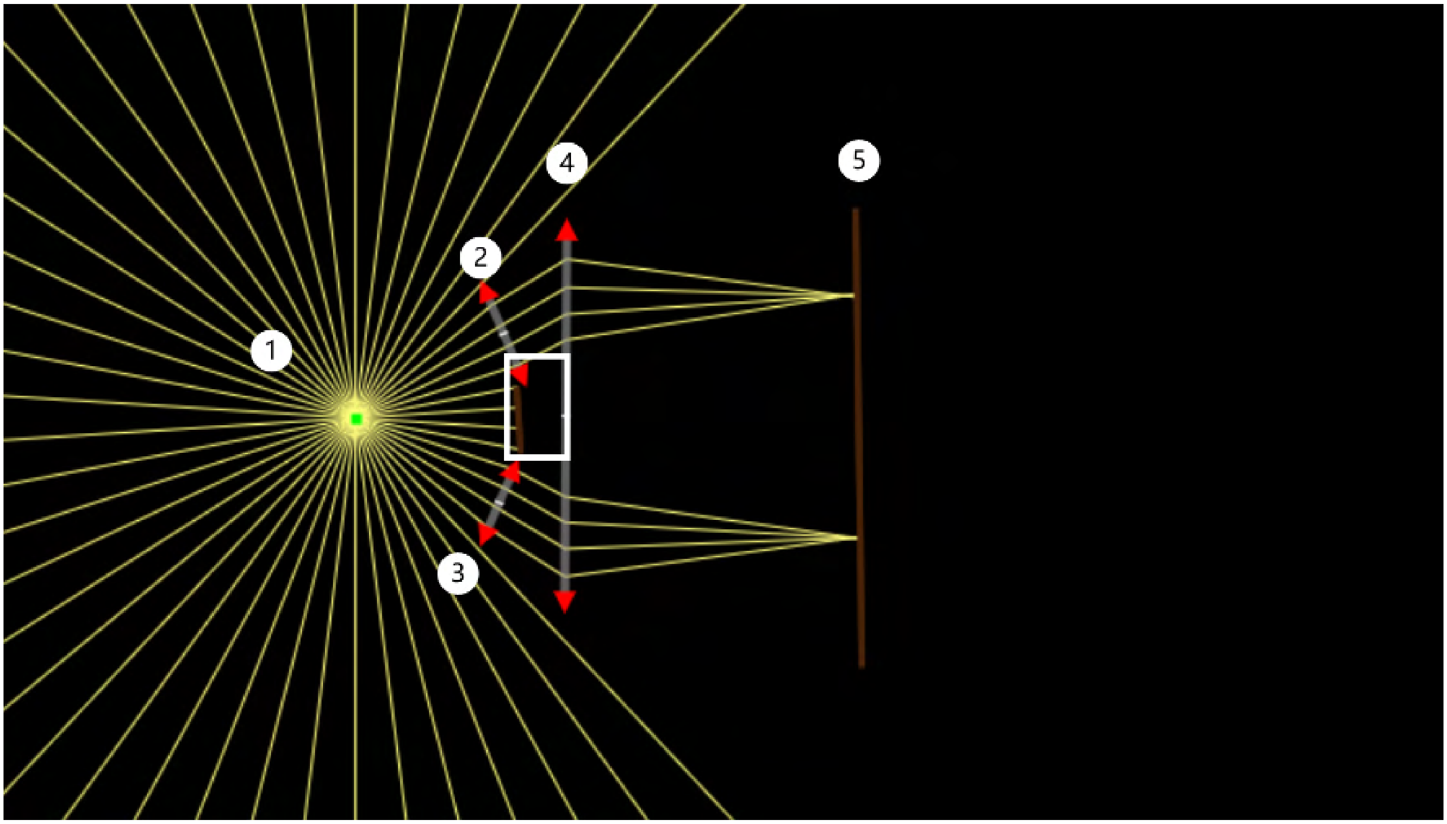


Figure 1: A splitting lens design, containing 1) Object of interest, 2) (The white block) Splitter to separate the views 3) Converging lens in the attachment, ideally have controllable angle to adjust the distance between the views on the sensor, 4) Lens of the smartphone, and 5) Sensor of the smartphone.

Rationale

The design is an attachment on the smartphone camera. Light reflected by the object will be splitted into two identical views. With the distance between resulting views adjusted, the depth perception from binocular microscope can be simulated with a single lens.

In reality, no adjustment on the distance is needed, since the pupil distance of human beings is constant.

The image captured by the smartphone can be then either filtered to produce anaglyph effect and viewed through 3D glasses, or directly streamlined to VR googles with monitors.

Conclusions/action items:

- Discuss this design with the team.
- Search for existing solutions

HAOCHEN WANG - Oct 11, 2021, 6:06 PM CDT

Title: Splitting Lens Design (Updated)

Date: 10/11/2021

Content by: Haochen Wang

Present: N/A

Goals: To improve the proposed final design

Content:

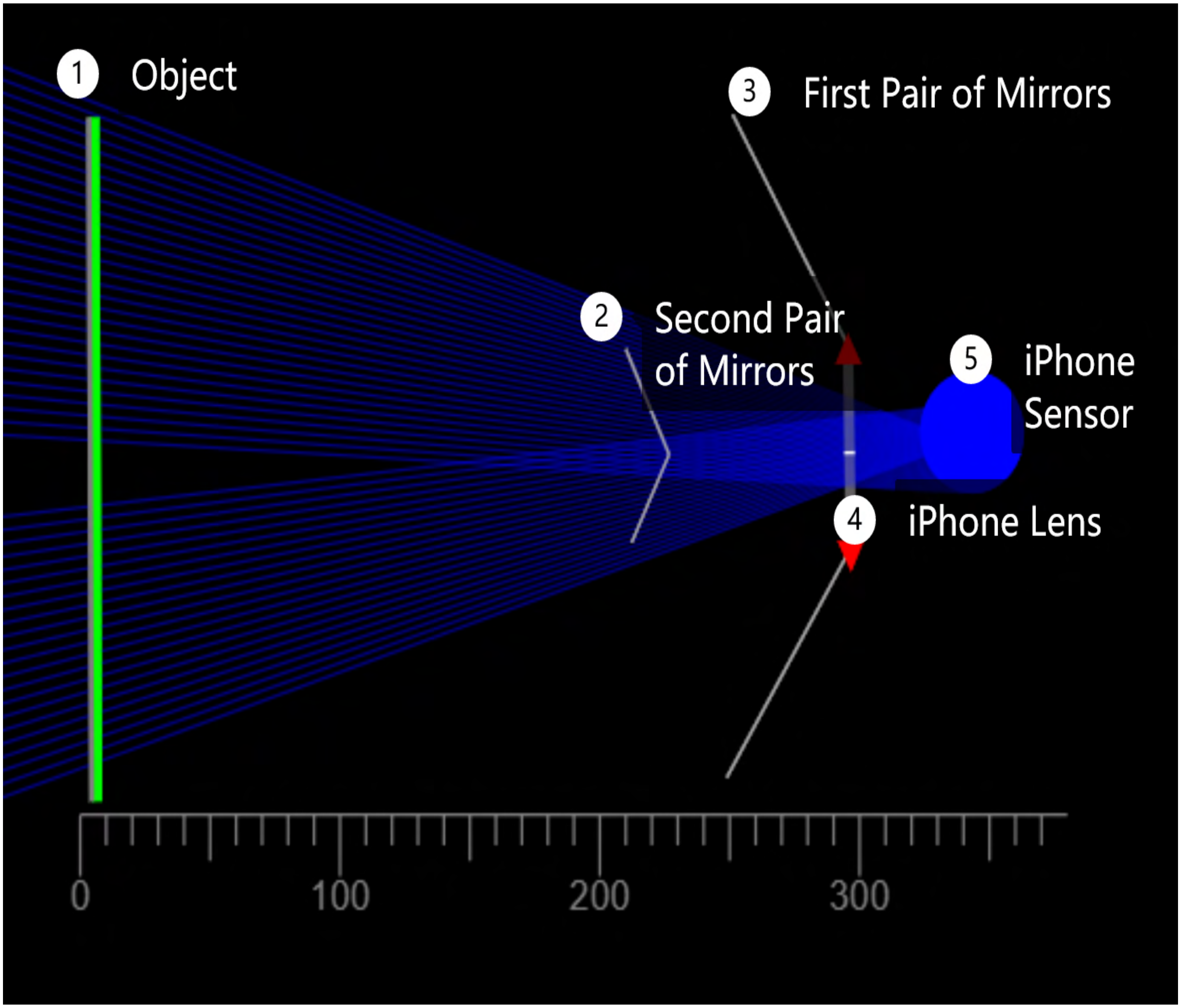


Figure 2: Set up for the updated design. The light reflected by the object (1) will be directed to a pair of mirrors (3), which are then reflected by the second pair of mirrors (2) through the camera lens (4) and to the sensor (5). Note that the diagram is not drawn in scale and the relative position of the components are subject to change.

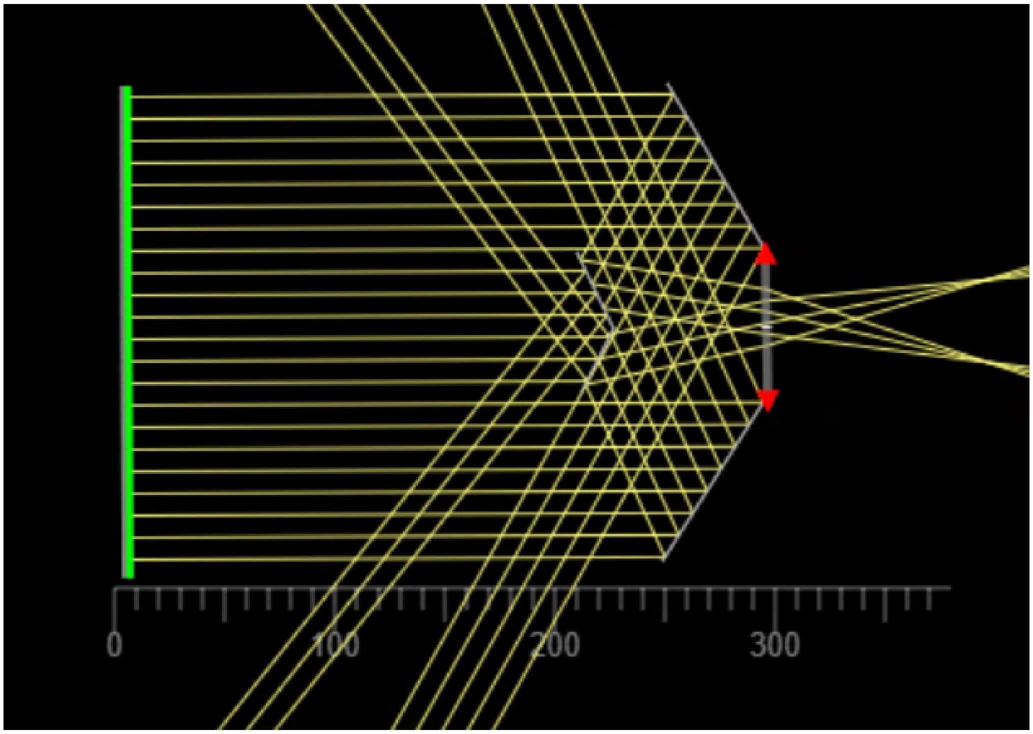


Figure 3: Ray tracking diagram for the updated design. Note that the diagram is not drawn in scale and the relative positions are subject to change.

<u>Rationale</u>

Due to price, lack of knowledge in optics calculation and image distortion, a more simple design is created with reflective mirrors. Seal *et al.* provided a detailed configuration and equations on the design. And the specifications will be checked against conclusions from Kyto *et al.*

Conclusions/action items:

- Discuss this design with the team.
- Continue calculation on desired parameters

2021/10/01-CMBF Design

HAOCHEN WANG - Oct 01, 2021, 12:49 PM CDT

Title: Splitting Lens Design

Date: 10/01/2021

Content by: Haochen Wang

Present: N/A

Goals: To introduce a CMBF design

Content:

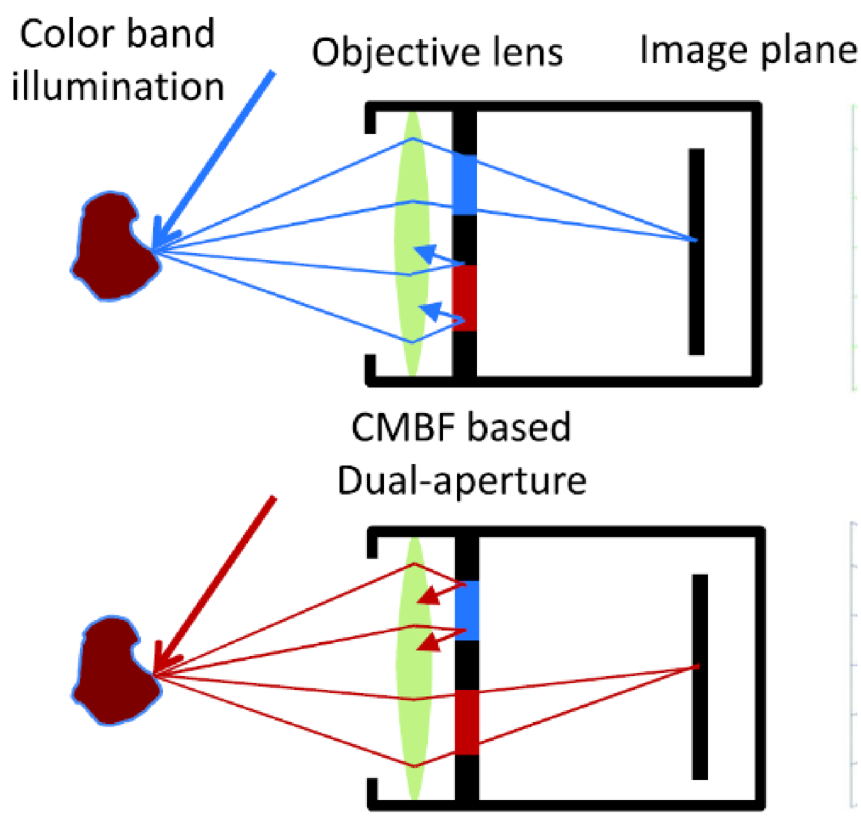


Figure 1: A CMBF design demonstration. Adopted form Bae et. al. *(2012).*

Rationale

The design is an attachment on the smartphone camera. As shown in Figure 1, the attachment consists of a converging lens for light redirection, while two CMBF filters are installed right after the lens to produce a resulting image with two fields of view, each with a unique spectrum. The resulting image will be displayed on a monitor, and the user will wear a polarized goggle to obtain depth perception. Note that according to the authors, the brain is capable of merging two spectrums together with minimal sacrifice in color representation quality.

The actual design will combine the figure above with splitting lens design.

Conclusions/action items:

- Discuss this design with the team.
- Search for existing solutions (since the paper is in experimental phase of the concept)

2021/10/01-Efficient Algorithm Design

HAOCHEN WANG - Oct 01, 2021, 1:25 PM CDT

Title: Efficient Algorithm Design

Date: 10/01/2021

Content by: Haochen Wang

Present: N/A

Goals: To introduce a design that enhances efficiency at the software level

Content:

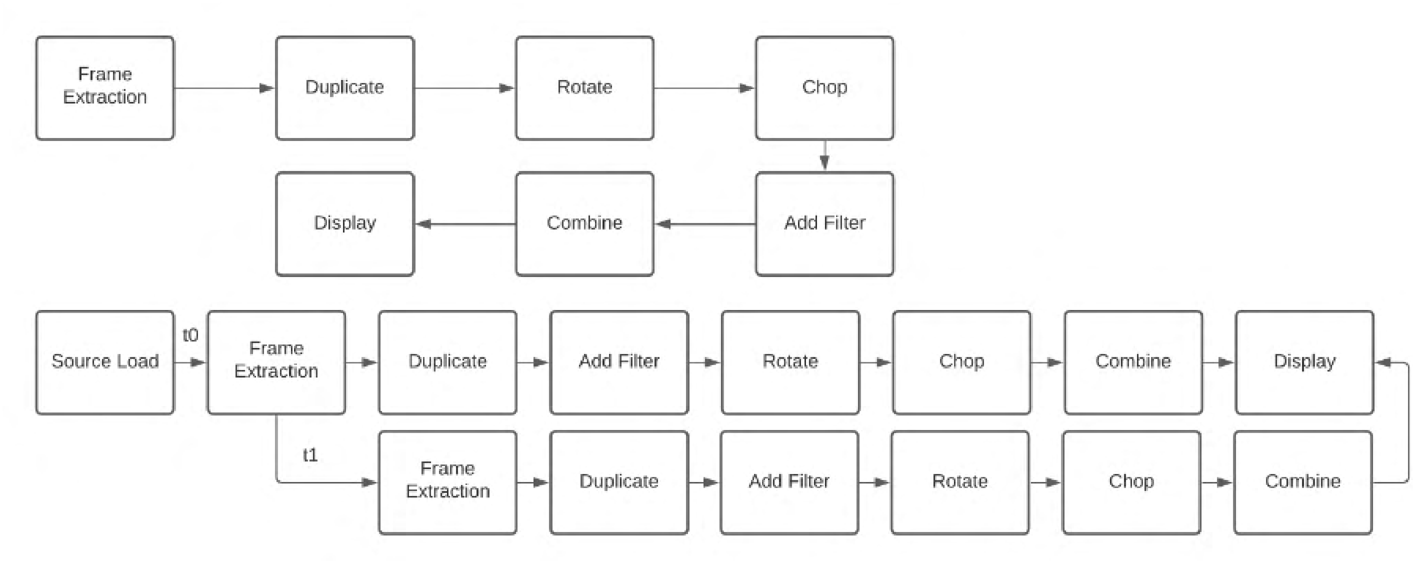


Figure 1: Top: Original algorithm developed by the previous team; Bottom: Proposed algorithm to enhance efficiency.

Rationale

The design is an update to the MATLAB code developed by the previous team. The proposed algorithm aims to utilize a buffer system, such that the streamlined video is extracted into frames while ensuring the frames are processed at the same time.

The efficiency of this algorithm is not yet known, yet stress on the hardware is expected to be reduced with decreased demand for RAM per iteration (by reducing variables stored in the workspace). Meanwhile, multi-threading process is expected to significantly reduce the process time.

Conclusions/action items:

- Discuss this design with the team.
- Search for existing solutions

2021/10/01-Autostereoscopic screen design

HAOCHEN WANG - Oct 01, 2021, 2:58 PM CDT

Title: Autostereoscopic screen design

Date: 10/01/2021

Content by: Haochen Wang

Present: N/A

Goals: To introduce a design that produces a 3D vision at the monitor

Content:

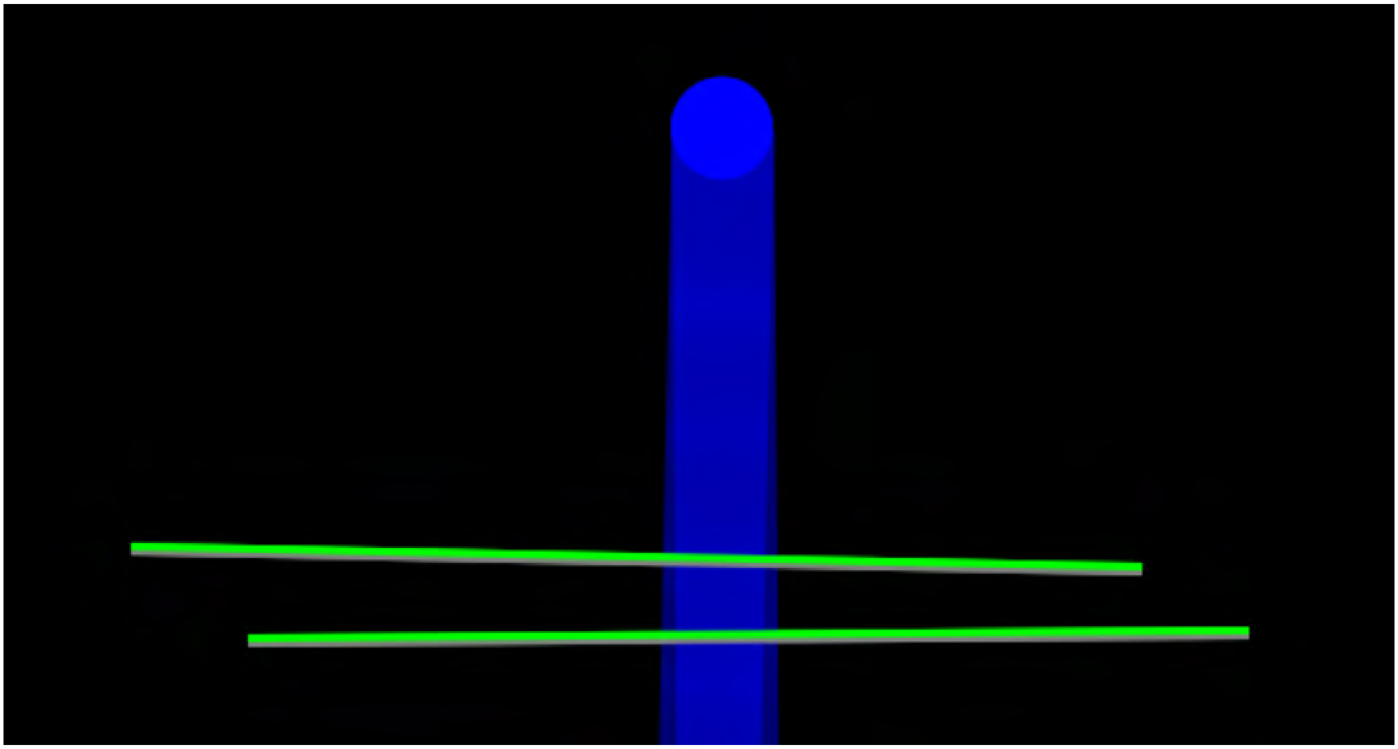


Figure 1: The monitor consist of two layers of LCD screens, each of which project the image to a single eye such that a 3D effect is produced.

Rationale

The design consist of a monitor with two built-in LCD screens. Each screen projects the image at a slight different angle, targeting at a single eye of the viewer. The depth resolution can be adjusted via the distance between the screens, yet only limited angle of view can be provided for a 3D effect.

Conclusions/action items:

- Discuss this design with the team.

2021/10/11-Calculations for Parameters for Proposed Final Design

HAOCHEN WANG - Oct 11, 2021, 5:26 PM CDT

Title: Calculation for Parameters for Proposed Final Design

Date: 10/11/2021

Content by: Haochen Wang

Present: N/A

Goals: To calculate the relative magnitude of the baseline

Content:

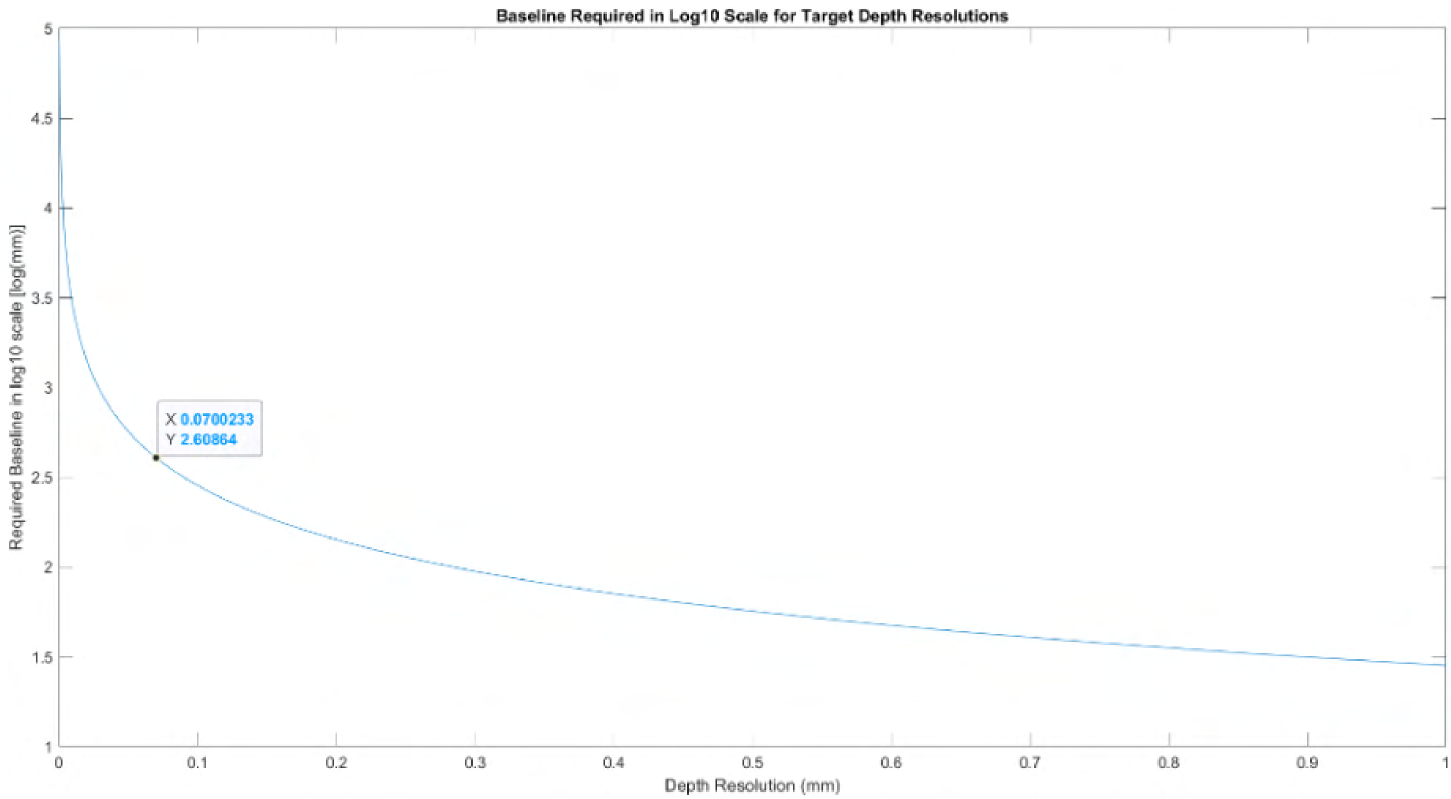


Figure 1: The baseline required (in a log10 scale) for target depth resolution. The diameter of the suture (minimal detectable size) is marked on the graph. The resulting baseline is 406 mm for the configuration.

Rationale

The graph is created to investigate a reasonable depth solution that results in a feasible size of the attachment to the phone.

Conclusions/action items:

- Discuss this design with the team.
- Upload the code when finished

HAOCHEN WANG - Oct 20, 2021, 12:44 AM CDT

Calculation_on_Optimal_Design.mlx(266.7 KB) - download

HAOCHEN WANG - Oct 20, 2021, 12:44 AM CDT

Investigation on Optimal Specifications of the Splitting Lens Design

Haochen Wang

Version: 1.0

Date of Last Update: 10/19/2021

```
close all;
clear;
clc;
```

Initialization

```
d_matrix = linspace(0,1,5000); %% Depth resolution in mm
lambda = 1.22E-03; %% Width of one pixel on the sensor of iPhone8
f = 3.99; %% iPhone 8 physical focal length
D = 305; %% Target working distance, 1 foot
D_matrix = 0:5000;
eta = 35; %% Value chosen from Seal et al.
phi = 1/3*pi; %% Value chosen from Seal et al.
epsilon = 4032 * lambda; %% Width of the camera sensor
alpha = 0:(pi/12):(pi/2);
eta_matrix = 0:0.1:100; %% unit: mm
Mo = zeros(7,length(eta_matrix));
w = zeros(7,length(eta_matrix));
l = zeros(7,length(eta_matrix));
A = zeros(7,length(eta_matrix));
```

Investigation on Optimal Baseline

```
z = D - d_matrix;
B = lambda*D./f./d_matrix.^2;
log_B = log10(B);
y1 = round(log_B,3,'decimals');
x1 = round(d_matrix,3,'significant');
plot (x1,y1)
title('Baseline Required in Log10 Scale for Target Depth Resolutions')
xlabel('Depth Resolution (mm)')
ylabel('Required Baseline in log10 scale (log(mm))')
ax = gca;
chart = ax.Children(1);
datatip(chart,0.070,2.609,'Location','northeast');
```

1

Wang_Haochen_Calculation_on_Optimal_Design.pdf(497.3 KB) - download

HAOCHEN WANG - Oct 20, 2021, 12:46 AM CDT

Title: Calculation for Parameters for Proposed Final Design, Code version 1.0

Date: 10/20/2021

Content by: Haochen Wang

Present: N/A

Goals: To calculate the relative magnitude of the baseline

Content:

Investigation on Optimal Specifications of the Splitting Lens Design

Haochen Wang

Version: 1.0

Date of Last Update: 10/19/2021

```
close all;

clear;

clc;
```

Initialization

```
d_matrix = linspace(0,1,5000); %% Depth resolution in mm

lambda = 1.22E-03; %% Width of one pixel on the sensor of iPhone8

f = 3.99; %% iPhone 8 physical focal length

D = 305; %% Target working distance, 1 foot

D_matrix = 0:1000;

eta = 35; %% Value chosen from Seal et al.

phi = 1/3*pi; %% Value chosen from Seal et al.

epsilon = 4032 * lambda; %% Width of the camera sensor

alpha = 0:(pi/12):(pi/2);

eta_matrix = 0:0.1:100; %% unit: mm

Mo = zeros(7,length(eta_matrix));

w = zeros(7,length(eta_matrix));

l = zeros(7,length(eta_matrix));

A = zeros(7,length(eta_matrix));
```

Investigation on Optimal Baseline

```
z = D - d_matrix;
```

```
B = lambda*D./f./d_matrix.*z;

log_B = log10(B);

y1 = round(log_B,3,'decimals');

x1 = round(d_matrix,3,'significant');

plot (x1,y1)

title('Baseline Required in Log10 Scale for Target Depth Resolutions')

xlabel('Depth Resolution (mm)')

ylabel('Required Baseline in log10 scale [log(mm)]')

ax = gca;

chart = ax.Children(1);

datatip(chart,0.070,2.609,'Location','northeast');
```

Investigate on Outter Mirror Angle and Mirror Lengths

```
Mi = epsilon * eta_matrix / (2 * f * sin(phi) - epsilon * cos(phi));

theta = atan(Mi * sin(phi) / (eta_matrix + Mi * cos(phi)));

for i = 1:length(alpha)

    Mo(i,:) = eta_matrix * sin(theta) * sin(phi) * sin(4*phi-2*alpha(i)-theta)...

        /sin(phi-theta)/sin(4*phi-2*alpha(i))/sin(2*phi-theta-alpha(i));

end
```

Calculate Overall Length and Width of the Attachment

```
for i = 1:length(alpha)

    w(i,:) = 2*Mo(i,:)*sin(alpha(i)) + 2*Mi*sin(phi);

    l(i,:) = max(Mo(i,:) * cos(phi), eta_matrix + Mi*cos(phi));

    A(i,:) = w(i,:).*l(i,:);

end
```

Plot eta versus area

```
x0 = eta_matrix;

y1 = log10(A(1,:));

y2 = log10(A(2,:));

y3 = log10(A(3,:));

y4 = log10(A(4,:));

y5 = log10(A(5,:));
```

```
y6 = log10(A(6,:));

y7 = log10(A(7,:));

plot(x0,y1,x0,y2,x0,y3,x0,y4,x0,y5,x0,y6,x0,y7)


legend('show')

title('Area in Log10 Scale versus Distance between Attachment and Lens')

xlabel('Distance between the attachment and the camera lens (mm)')

ylabel('Cross-sectional area of the attachment (log10(mm^2))')


legend({'alpha = 0','alpha = pi/12','alpha = pi/6','alpha = pi/4',...

    'alpha = pi/3','alpha = 5pi/12','alpha = pi/2'})

set(legend,...

    'Position',[0.654880949145271 0.450317454277525 0.226785717521395 0.270000006039937])
```

Conclusions/action items:

- Discuss this design with the team.
- See attachment for code running results

HAOCHEN WANG - Oct 20, 2021, 1:38 AM CDT

Title: Calculation for Parameters for Proposed Final Design, Formulas used for code 1.0

Date: 10/20/2021

Content by: Haochen Wang

Present: N/A

Goals: To show derivation of the formulas used in the code

Content:

Assumptions and constants set for the calculations

- f = 3.99 mm, this is the actual focal length (not the equivalent focal length) of the iPhone camera [2]
- epsilon = 4032 x 3.99 mm = 16087 mm, this is the width of the camera sensor [2]
- Lamba = 1.22E-03 mm, which is the size of one pixel in the sensor [2]. This determines the minimum depth perception in the video.
- D = 305 mm, this is the working distance (1 foot) claimed by the clients.
- Phi = pi/3 (60 degrees), this is the angle between the first pair of mirrors and the horizontal line. The value is concluded by Seal *et al*. that produces least amount of occlusion [2]

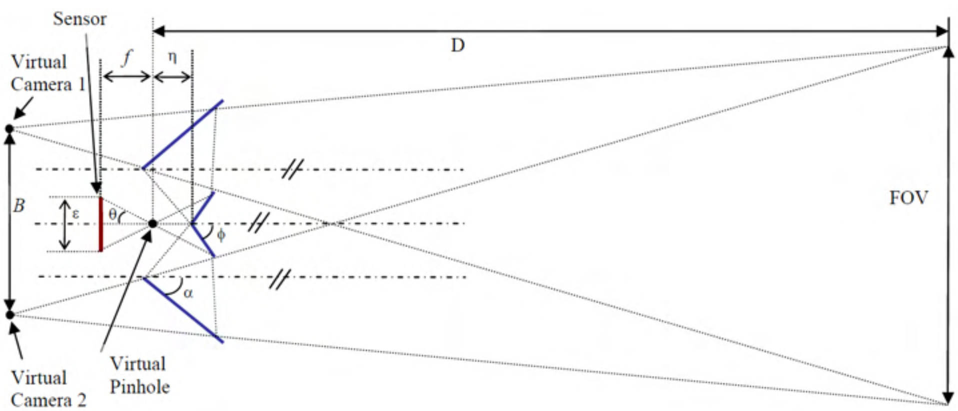


Figure 1: The catadioptric system showing the position of mirrors, sensor, lens and definitions of the parameters. Adapted from Seal et al *[1].*

Formula for the Length of Second Pair of Mirrors (Mi) in Figure x

By similar triangles,

$$\frac{f}{\eta + Mi * \cos(\phi)} = \frac{\epsilon}{2Mi * \sin(\phi)} \qquad Eq(1)$$

$$Mi = \frac{\epsilon\eta}{2f sin(\phi) - \epsilon \cos(\phi)} \qquad Eq(2)$$

Where Mi is the length of each mirror in the second pair of mirrors in mm. All other parameters are shown in the figure above. f is the actual focal length of iPhone 8 (3.99 mm) [2]. Epsilon is calculated by multiplying 4032 pixels to the length of each pixel (1.22E-03 mm) [2]. Eta is the distance between the vertex of the second pair of mirrors and the camera lens (varying from 0 mm to 100 mm with 0.1 mm increment). Phi is the angle formed between the horizontal line and one of the second-pair mirrors (pi/3 radians). These two values are adopted from Seal *et al.* for the most compact settings that have some flexibility to compensate fabrication errors [1].

Calculation on angle (theta) formed by the extended ray from the sensor that passes through the pinhole (center of the smartphone camera lens)

$$Mi = \eta \frac{sin\theta}{\sin(\phi - \theta)} = \eta \frac{sin\theta}{sin\phi\ cos\theta - cos\phi\ sin\theta} = \frac{\eta}{\frac{sin\phi}{tan\theta} - cos\phi} \qquad Eq(3)$$

$$\theta = \tan^{-1} \frac{Mi\ sin\phi}{\eta + Mi\ cos\phi} \qquad Eq(4)$$

Where theta is the tangential angle formed by the extended ray from the sensor that passes through the pinhole (center of the smartphone camera lens) in radians.

Length of the second pair of mirrors (Mo, in mm) with varying angles between the horizontal line

Adopted from Seal *et al.* [1]

$$Mo = \eta \frac{sin\theta\ sin\phi \sin(4\phi - 2\alpha - \theta)}{\sin(\phi - \theta)\sin(4\phi - 2\alpha)\sin(2\phi - \theta - \alpha)} \qquad Eq(5)$$

Where Mo is the length of the second pair of mirrors in mm. Alpha (in radians) is the angle formed between the horizontal line and each of the mirrors in radians. Alpha is unable to calculate directly from previous assumptions, thus is set as varying angle from 0 to pi/2 with increments of pi/12,

Overall size (length and width in mm) of the attachment from proposed final design

$$w = 2Mo\sin(\alpha) + 2Mi\sin(\phi) \qquad Eq(6)$$

$$l = \begin{cases} Mo\ cos\phi\ (Mo\ cos\alpha \geq \eta + Mi\ cos\phi) \\ \eta + Mi\ cos\phi\ (otherwise) \end{cases} \qquad Eq(7)$$

Where w is the width of the attachment in mm, and l is the length of the attachment in mm.
Thus, the area occupied in the x-y plane (horizontal plane) is:

$$A = wl \qquad Eq(8)$$

Investigation on feasible baseline size

Baseline is the distance between two virtual According to Seal *et al.*, the baseline size can be calculated as

$$B = \frac{\lambda D}{fd}(D - d) \qquad Eq(9)$$

D is the targeting working distance specified by the clients (305 mm, 1 foot), lambda is the width of one pixel (1.22 microns) on the sensor of iPhone8, f is the actual focal length (2.99 mm) of iPhone 8 [2]. d is the independent variable, which is the expected depth perception that a user can detect.

Reference

[1] J. Seal, D. Bailey, and G. Sen Gupta, “Depth perception with a single camera,” 2005.

[2] “IPhone 8 sensor size,” *iPhone 8 sensor size: iOS Talk Forum: Digital Photography Review*, 22-Sep-2017. [Online]. Available: https://www.dpreview.com/forums/post/60151245. [Accessed: 20-Oct-2021].

Conclusions/action items:

- Discuss the calculation steps with the other group members

Title: Calculation for Parameters for Proposed Final Design, Code version 1.1

Date: 10/28/2021

Content by: Haochen Wang

Present: N/A

Goals: To calculate the relative magnitude of the baseline

Content:

Investigation on Optimal Specifications of the Splitting Lens Design
Haochen Wang
Version: 1.1
Date of Last Update: 10/28/2021

Update Notes:

1.1: Fixed an error in constant definition (theta), rearranged equations to get correct values of the design. Added a new plot for log(area) versus eta to determine the alpha value resulting in the most compact design.

```
close all;
clear;
clc;
Initialize Constants
lambda = 1.22E-03; %% Width of one pixel on the sensor of iPhone8
f = 3.99; %% iPhone 8 physical focal length
D = 305; %% Target working distance, 1 foot
epsilon = 4032 * lambda; %% Width of the camera sensor
eta = 35; %% Value chosen from Seal et al.
%phi = 1/3*pi; %% Value chosen from Seal et al.
theta = atan(epsilon / 2 / f);
FOV = D * tan(theta);
phi = atan(epsilon*(sin(theta)-1)/(epsilon*cos(theta)-2*f));
Initialize Arrays
alpha = 0:(pi/12):(pi/2);
% D_matrix = 0:1000;
d_matrix = linspace(0,1,5000); %% Depth resolution in mm
eta_matrix = 0:0.5:100; %% unit: mm
Mo = zeros(7,length(eta_matrix));
w = zeros(7,length(eta_matrix));
l = zeros(7,length(eta_matrix));
B_matrix = zeros(7,length(eta_matrix));
x = zeros(7,length(eta_matrix));
Mi = eta_matrix * sin(theta) / sin(phi-theta);
```

```
Investigation on Optimal Baseline
z = D - d_matrix;
B = lambda*D./f./d_matrix.*z;
log_B = log10(B);
y1 = round(log_B,3,'decimals');
x1 = round(d_matrix,3,'significant');
figure(1);
```

```
plot (x1,y1)
title('Baseline Required in Log10 Scale for Target Depth Resolutions')
xlabel('Depth Resolution (mm)')
ylabel('Required Baseline in log10 scale [log(mm)]')
ax = gca;
chart = ax.Children(1);
datatip(chart,0.070,2.609,'Location','northeast');
```

Investigate on Outter Mirror Angle and Mirror Lengths

```
d = 0.070;
for i = 1:length(alpha)
   B_matrix(i,:) = 2*sin(2*phi-2*alpha(i)).*eta_matrix ...
      .*(1+sin(theta)/sin(phi-theta).*(sin(phi)/sin(2*phi-2*alpha(i)) ...
      +sin(3*phi-2*alpha(i)+sin(phi))./sin(4*phi-2*alpha(i))));
   Mo(i,:) = eta_matrix * sin(theta) * sin(phi) .* sin(4*phi-2*alpha(i)-theta)...
      /sin(phi-theta)./sin(4*phi-2*alpha(i))./sin(2*phi-theta-alpha(i));
end
```

Calculate Overall Length and Width of the Attachment

```
for i = 1:length(alpha)
%     x = (eta_matrix*tan(pi-2*phi)-y)/tan(pi-2*phi);
   for j = 1:length(eta_matrix)
      syms y positive
      eqn = (cos(alpha(i))*(cos(phi)*Mi(j)+eta_matrix(j)-(eta_matrix(j)*tan(pi-2*phi)-y)/tan(pi-2*phi)) ...
         +sin(alpha(i))*(sin(phi)*Mi(j)-y)) ./ sqrt((cos(phi)*Mi(j)+eta_matrix(j)-(eta_matrix(j)*tan(pi-2*phi)-y)/tan(pi-
2*phi)).^2 ...
         + (sin(phi)*Mi(j)-y).^2) - (cos(alpha(i))*((eta_matrix(j)*tan(pi-2*phi)-y)/tan(pi-2*phi)-eta_matrix(j)) ...
         + sin(alpha(i))*y) ./ sqrt(((eta_matrix(j)*tan(pi-2*phi)-y)/tan(pi-2*phi)-eta_matrix(j)).^2 + y.^2) ==0;
      temp = solve(eqn,y);
      for k = 1:length(temp)
         if (temp(k) > 0) && (temp(k) < 50)
            x(i,j) = temp(k);
         else
            x(i,j) = -99999;
         end
      end

   end
   w(i,:) = 2*Mo(i,:)*sin(alpha(i)) + 2*x(i,:);
   l(i,:) = max(Mo(i,:) * cos(phi), eta_matrix + Mi*cos(phi));
   A(i,:) = w(i,:).*l(i,:);
end
```

Plot eta versus area

```
x0 = eta_matrix;
y1 = log10(A(1,:));
y2 = log10(A(2,:));
y3 = log10(A(3,:));
y4 = log10(A(4,:));
y5 = log10(A(5,:));
y6 = log10(A(6,:));
y7 = log10(A(7,:));
```

```
figure(2);
plot(x0,y1,x0,y2,x0,y3,x0,y4,x0,y5,x0,y6,x0,y7)


legend('show')
title('Area in Log10 Scale versus Distance between Attachment and Lens')
xlabel('Distance between the attachment and the camera lens (mm)')
ylabel('Cross-sectional area of the attachment (log10(mm^2))')


legend({'alpha = 0','alpha = pi/12','alpha = pi/6','alpha = pi/4',...
    'alpha = pi/3','alpha = 5pi/12','alpha = pi/2'})
set(legend,...
    'Position',[0.654880949145271 0.450317454277525 0.226785717521395 0.270000006039937])


Further determination on the most compact design
% figure(3);
% plot(x0,y2,x0,y4,x0,y5,x0,y6)
% legend('show')
% title('Area in Log10 Scale versus Distance between Attachment and Lens')
% xlabel('Distance between the attachment and the camera lens (mm)')
% ylabel('Cross-sectional area of the attachment (log10(mm^2))')
%
% legend({'alpha = pi/12','alpha = pi/4',...
%     'alpha = pi/3','alpha = 5pi/12'})
% set(legend,...
%     'Position',[0.637738092002414 0.201746025706097 0.226785717521395 0.270000006039938]);
```

Conclusions/action items:

- Discuss the calculation steps with the other group members

Title: Calculation for Parameters for Proposed Final Design, Code version 1.2

Date: 11/01/2021

Content by: Haochen Wang

Present: N/A

Goals: To calculate the relative magnitude of the baseline

Content:

Investigation on Optimal Specifications of the Splitting Lens Design

Haochen Wang

Version: 1.2

Date of Last Update: 11/01/2021

Update Notes:

1.2: Fixed an error in calculating position of the outter mirror (the edge of the mirror that is closest to the camera lens). Added new algorithm discarding negative values of mirror length(s). Determined the proposed final specifications.

1.1: Fixed an error in constant definition (theta), rearranged equations to get correct values of the design. Added a new plot for log(area) versus eta to determien the alpha value resulting in the most compact design.

close all;

clear;

clc;

Initialize Constants

lambda = 1.22E-03; %% Width of one pixel on the sensor of iPhone8

f = 3.99; %% iPhone 8 physical focal length

D = 305; %% Target working distance, 1 foot

epsilon = 4032 * lambda; %% Width of the camera sensor

eta = 35; %% Value chosen from Seal et al.

phi = 1/3*pi; %% Value chosen from Seal et al.

theta = atan(epsilon / 2 / f);

FOV = D * tan(theta);

Initialize Arrays

alpha = 0:(pi/12):(pi/2);

% D_matrix = 0:1000;

d_matrix = linspace(0,1,5000); %% Depth resolution in mm

eta_matrix = 0:0.5:100; %% unit: mm

```
Mo = zeros(7,length(eta_matrix));

w = zeros(7,length(eta_matrix));

l = zeros(7,length(eta_matrix));

B_matrix = zeros(7,length(eta_matrix));

x = zeros(7,length(eta_matrix));

Mi = eta_matrix * sin(theta) / sin(phi-theta);
```

Investigation on Optimal Baseline

```
z = D - d_matrix;

B = lambda*D./f./d_matrix.*z;

log_B = log10(B);

y1 = round(log_B,3,'decimals');

x1 = round(d_matrix,3,'significant');

figure(1);

plot (x1,y1)

title('Baseline Required in Log10 Scale for Target Depth Resolutions')

xlabel('Depth Resolution (mm)')

ylabel('Required Baseline in log10 scale [log(mm)]')

ax = gca;

chart = ax.Children(1);

datatip(chart,0.070,2.609,'Location','northeast');
```

Investigate on Outter Mirror Angle and Mirror Lengths

```
d = 0.070;

for i = 1:length(alpha)

    B_matrix(i,:) = 2*sin(2*phi-2*alpha(i))*eta_matrix ...

        *(1+sin(theta)/sin(phi-theta)*(sin(phi)/sin(2*phi-2*alpha(i)) ...

        +sin(3*phi-2*alpha(i)+sin(phi))/sin(4*phi-2*alpha(i))));

    Mo(i,:) = eta_matrix * sin(theta) * sin(phi) * sin(4*phi-2*alpha(i)-theta)...

        /sin(phi-theta)/sin(4*phi-2*alpha(i))/sin(2*phi-theta-alpha(i));

end
```

Calculate Overall Length and Width of the Attachment

```
for i = 1:length(alpha)
%     x = (eta_matrix*tan(pi-2*phi)-y)/tan(pi-2*phi);
    for j = 1:length(eta_matrix)
        syms y positive
        eqn = (cos(alpha(i))*(cos(phi)*Mi(j)+eta_matrix(j)-(eta_matrix(j)*tan(pi-2*phi)-y)/tan(pi-2*phi)) ...
            +sin(alpha(i))*(sin(phi)*Mi(j)-y)) ./ sqrt((cos(phi)*Mi(j)+eta_matrix(j)-(eta_matrix(j)*tan(pi-2*phi)-y)/tan(pi-
2*phi)).^2 ...
            + (sin(phi)*Mi(j)-y).^2) - (cos(alpha(i))*((eta_matrix(j)*tan(pi-2*phi)-y)/tan(pi-2*phi)-eta_matrix(j)) ...
            + sin(alpha(i))*y) ./ sqrt(((eta_matrix(j)*tan(pi-2*phi)-y)/tan(pi-2*phi)-eta_matrix(j)).^2 + y.^2) ==0;
        temp = double(subs(solve(eqn,y)));
        for k = 1:length(temp)
            if (temp(k) > 0) && (temp(k) < 50)
                x(i,j) = temp(k);
            else
                x(i,j) = -99999;
            end
        end


    end
    w(i,:) = 2*Mo(i,:)*sin(alpha(i)) + 2*x(i,:);
    l(i,:) = max(Mo(i,:) * cos(phi), eta_matrix + Mi*cos(phi));
    A(i,:) = w(i,:).*l(i,:);
end
```

Plot eta versus area

```
x0 = eta_matrix;
y1 = log10(A(1,:));
y2 = log10(A(2,:));
y3 = log10(A(3,:));
```

```
y4 = log10(A(4,:));

y5 = log10(A(5,:));

y6 = log10(A(6,:));

y7 = log10(A(7,:));

figure(2);

% Jump in the plot occurs when the acutal width of the desgin becomes eta +

% Mi*cos(phi), since eta becomes larger and thus the dominating parameter

% in the width.

plot(x0,y1,x0,y2,x0,y3,x0,y4,x0,y5,x0,y6,x0,y7)


legend('show')

title('Area in Log10 Scale versus Distance between Attachment and Lens')

xlabel('Distance between the attachment and the camera lens (mm)')

ylabel('Cross-sectional area of the attachment (log10(mm^2))')


legend({'alpha = 0','alpha = pi/12','alpha = pi/6','alpha = pi/4',...

    'alpha = pi/3','alpha = 5pi/12','alpha = pi/2'})

set(legend,...

    'Position',[0.649880949145270 0.53317459713467 0.226785717521395 0.270000006039939])
```

Further determination on the most compact design

```
figure(3);

% Jump in the plot occurs when the acutal width of the desgin becomes eta +

% Mi*cos(phi), since eta becomes larger and thus the dominating parameter

% in the width.

plot(x0,y2,x0,y3,x0,y4,x0,y5,x0,y6)

legend('show')

title('Area in Log10 Scale versus Distance between Attachment and Lens')

xlabel('Distance between the attachment and the camera lens (mm)')

ylabel('Cross-sectional area of the attachment (log10(mm^2))')
```

```
legend({'alpha = pi/12','alpha = pi/6','alpha = pi/4',...
    'alpha = pi/3','alpha = 5pi/12'})
set(legend,...
    'Position',[0.649880949145271 0.428412692372764 0.226785717521395 0.270000006039938]);
```

Examination on calculated values

```
figure(4)
plot(x0,Mi)
xlim([0.0 100.0])
ylim([0 120])
title('Length of Inner Mirror versus Eta Values at alpha = 60 deg')
xlabel('Distance between the attachment and the camera lens (eta, mm)')
ylabel('Inner Mirror Length (Mi, mm)')

figure(5)
plot(x0,Mo(2,:),x0,Mo(4,:),x0,Mo(5,:),x0,Mo(6,:))
legend({'alpha = pi/12','alpha = pi/4','alpha = pi/3','alpha = 5pi/12'})
title('Outer Mirror Length versus eta values')
xlabel('Distance between the attachment and the camera lens (eta, mm)')
ylabel('Outer Mirror Length (Mo, mm)')
set(legend,...
    'Position',[0.652023805649549 0.258650754743244 0.226785717521395 0.157857146308536])
figure(6)
plot(x0,x(5,:))
xlim([0.0 100.0])
ylim([-100000 20000])
xlabel('Distance between camera lens and the attachment (eta, mm)')
ylabel(['Vertical distance between the outer mirror '; ...
    'and the lens(x, mm)                          ']);
title(['Distance between outer mirror and     '; ...
```

```
    'the lens versus eta for alpha = 60 deg']);

figure(7)

% All angles were tested, yet only alpha = 60 deg can provide a positive

% baseline value based on the restrictions

plot(x0,B_matrix(5,:))

title('Baseline versus eta for alpha = 60 deg')

xlabel('Distance between the camera lens and the attachment (eta, mm)')

ylabel('Baseline from the configuration (B, mm)')


Finalized Specifications

final_eta = eta_matrix(11) % in mm

final_lamda = lambda % in mm

final_f = f % in mm

final_D = D % in mm

final_epsilon = epsilon % in mm

final_theta = rad2deg(theta) % theta in degrees

final_FOV = FOV % in mm

final_phi = rad2deg(phi) % phi in degrees

final_d = d % in mm

final_alpha = rad2deg(alpha(5)) % alpha in degrees

final_Mi = Mi(11) % in mm

final_Mo = Mo(5,11) % in mm

final_x = x(5,11) % in mm

final_B = B_matrix(5,11) % in mm

final_w = w(5,11) % in mm

final_l = l(5,11) % in mm

final_A = A(5,11) % in mm^2

final_h = 3024/4032*final_w % in mm, height of each mirror
```

Conclusions/action items:

- Discuss the calculation steps with the other group members

HAOCHEN WANG - Nov 01, 2021, 2:26 PM CDT

Investigation on Optimal Specifications of the Splitting Lens Design

Haochen Wang

Version: 1.2

Date of Last Update: 11/01/2021

Update Notes:

1.2: Fixed an error in calculating position of the outer mirror (the edge of the mirror that is closest to the camera lens). Added new algorithm discarding negative values of mirror length(s). Determined the proposed final specifications.

1.1: Fixed an error in constant definition (theta), rearranged equations to get correct values of the design. Added a new plot for b(pixel) versus eta to determine the alpha value resulting in the most compact design.

```
close all;
clear;
clc;
```

Initialize Constants

```
lambda = 1.22E-03; %% Width of one pixel on the sensor of iPhone8
f = 3.99; %% iPhone 8 physical focal length
D = 305; %% Target working distance, 1 foot
epsilon = 4032 * lambda; %% Width of the camera sensor
eta = 26; %% Value chosen from Seal et al.
phi = 1/3*pi; %% Value chosen from Seal et al.
theta = atan(epsilon / 2 / f);
FOV = D * tan(theta);
```

Initialize Arrays

```
alpha = 0:(pi/12):(pi/2);
% D_matrix = 0:2000;
d_matrix = linspace(0,1,5000); %% Depth resolution in mm
eta_matrix = 0:0.5:200; %% unit: mm
Mo = zeros(7,length(eta_matrix));
w = zeros(7,length(eta_matrix));
l = zeros(7,length(eta_matrix));
B_matrix = zeros(7,length(eta_matrix));
s = zeros(7,length(eta_matrix));
Mi = eta_matrix * sin(theta) / sin(phi-theta);
```

Investigation on Optimal Baseline

```
z = D - d_matrix;
B = lambda*D./f./d_matrix.^2;
log_B = log10(B);
y1 = round(log_B,3,'decimals');
x1 = round(d_matrix,3,'significant');
figure(1);
```

1

Wang_Haochen_Calculation_on_Optimal_Design_1.2.pdf(1.4 MB) - download

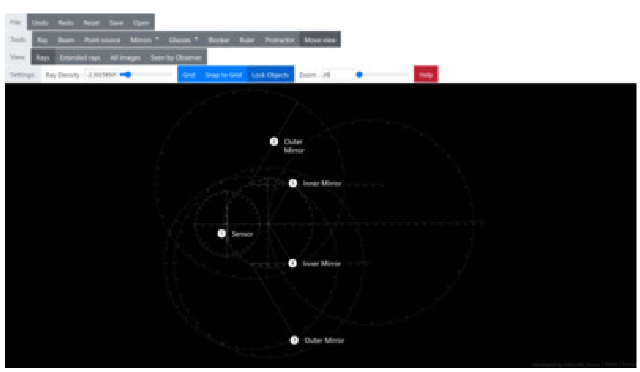
HAOCHEN WANG - Nov 01, 2021, 2:26 PM CDT

Calculation_on_Optimal_Design.mlx(845.9 KB) - download

HAOCHEN WANG - Nov 02, 2021, 7:01 PM CDT

Final_Design_03-1.json(3.6 KB) - download The attachments are template for optics simulation on the proposed final design. The image shows the arrangement and positioning of the mirrors, and the json file is shared with the group for testing with individualized imaging conditions.

HAOCHEN WANG - Nov 02, 2021, 7:01 PM CDT



Draft_Simulation.png(444.3 KB) - download The attachments are template for optics simulation on the proposed final design. The image shows the arrangement and positioning of the mirrors, and the json file is shared with the group for testing with individualized imaging conditions.

HAOCHEN WANG - Dec 15, 2021, 12:16 AM CST

Investigation on Optimal Specifications of the Splitting Lens Design

Haochen Wang

Version: 1.4

Date of Last Update: 12/14/2021

Update Notes:

1.4 Fixed figure labels and reset the scales

1.3: Added horizontal position of the outer mirror relative to the virtual pinhole

1.2: Fixed an error in calculating position of the outer mirror (the edge of the mirror that is closest to the camera lens). Added new algorithm discarding negative values of mirror length (s). Determined the proposed final specifications.

1.1: Fixed an error in constant definition (theta), rearranged equations to get correct values of the design. Added a new plot for b g(area) versus eta to determien the alpha value resulting in the most compact design.

```
close all;
clear;
clc;
```

Initialize Constants

```
lambda = 1.22E-03; %% Width of one pixel on the sensor of iPhone8
f = 3.99; %% iPhone 8 physical focal length
D = 305; %% Target working distance, 1 foot
epsilon = 4032 * lambda; %% Width of the camera sensor
eta = 36; %% Value chosen from Seal et al.
phi = 1/3*pi; %% Value chosen from Seal et al.
theta = atan(epsilon / 2 / f);
FOV = D * tan(theta);
```

Initialize Arrays

```
alpha = 0:(pi/12):(pi/2);
% D_matrix = 0:3000;
d_matrix = linspace(0,1,5000); %% Depth resolution in mm
eta_matrix = 0:0.5:300; %% unit: mm
Mo = zeros(7,length(eta_matrix));
w = zeros(7,length(eta_matrix));
l = zeros(7,length(eta_matrix));
B_matrix = zeros(7,length(eta_matrix));
x = zeros(7,length(eta_matrix));
Mi = eta_matrix * sin(theta) / sin(phi-theta);
```

Investigation on Optimal Baseline

```
z = D - d_matrix;
B = lambda*D./f./d_matrix.^2;
log_B = log10(B);
```

1

Calculation_on_Optimal_Design_ver.1.4.pdf(1.4 MB) - download Updated axis scales, resolved the issue with log-scale confusion.

2021/03/14-BioSafety Training Record

HAOCHEN WANG - Mar 14, 2021, 1:40 PM CDT

Title: BioSafety Training Record

Date: 03/14/2021

Content by: Haochen Wang

Present: N/A

Goals: To gain more knowledge on bio-safety requirements and precautions in labs

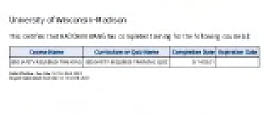
Content:

See attachment for proof

Conclusions/action items:

Review training recordings prior to future labs

HAOCHEN WANG - Mar 14, 2021, 1:43 PM CDT



University of Wisconsin-Madison

[illegible]

Course Name	Curriculum or Quiz Name	Completion Date	Expiration Date
[illegible]	[illegible]	[illegible]	

BioSafety-_Certificate_of_Completion_for_HAOCHEN_WANG.pdf(114.2 KB) - download

2021/03/28-Chemistry Safety Training Record

HAOCHEN WANG - Mar 28, 2021, 10:40 PM CDT

Title: Chem Safety Training Record

Date: 03/28/2021

Content by: Haochen Wang

Present: N/A

Goals: To gain more knowledge on chem-safety requirements and precautions in labs

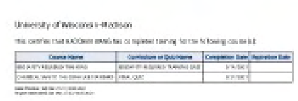
Content:

See attachment for proof

Conclusions/action items:

Review training recordings prior to future labs

HAOCHEN WANG - Mar 28, 2021, 10:40 PM CDT



University of Wisconsin-Madison

Course Name	Curriculum or Quiz Name	Completion Date	Expiration Date
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	

Chemical_Safety_and_Biosafety_Certificate_of_Completion_for_HAOCHEN_WANG.pdf(115.8 KB) - download

2021/10/10 Micro Lens Array

HENRY PLAMONDON - Oct 19, 2021, 8:32 PM CDT

Title: Micro Lens Array for 3D Vision with one Camera

Date: 10/10/2021

Content by: Myself

Present: Myself

Goals: Learn about the technique of using a micro lens array to create 3D vision with one camera lens

Content:

Article Title: Single lens 3D-camera with extended depth-of-field

IEEE Citation:

C. Perwaß and L. Wietzke, “Single lens 3D-camera with extended depth-of-field,” *SPIE Digital Library*, 17-Feb-2012. [Online]. Available: https://www.spiedigitallibrary.org/conference-proceedings-of-spie/8291/1/Single-lens-3D-camera-with-extended-depth-of-field/10.1117/12.909882.short?SSO=1. [Accessed: 10-Oct-2021].

This article was helpful in that it introduced me to a new technique for creating 3D imagery with a single lens. It also introduces a new finding in creating depth perception. This can be helpful in further research about micro lens arrays and new techniques for creating more depth within a 3D display.

Conclusions/action items:

This helps me further my research by introducing me to micro lens arrays. I will continue to look into this concept and hopefully will find some new articles regarding this topic and how the team may be able to implement it.

2021/10/10 Continue Micro Lens Array

HENRY PLAMONDON - Oct 19, 2021, 8:52 PM CDT

Title: Fabrication of Microlens Array and Its Application: A Review

Date: 10/10/2021

Content by: Myself

Present: Myself

Goals: Learn more about how to fabricate microlens arrays

Content:

Article Title: Fabrication of Microlens Array and Its Application: A Review

IEEE Citation:

W. Yuan, L.-H. Li, W.-B. Lee, and C.-Y. Chan, “Fabrication of microlens array and its application: A Review,” *Chinese Journal of Mechanical Engineering*, 27-Feb-2018. [Online]. Available: https://link.springer.com/article/10.1186/s10033-018-0204-y. [Accessed: 10-Oct-2021].

I found that the fabrication of these lenses takes a serious amount of calculations and is most likely an expensive process. If we had a much larger budget and much more time to refine the calculations, this would most likely be the best and most precise answer to creating this prototype. If there is a way to create a similar concept for much cheaper and in a shorter time but slightly lower in quality, we could look into that and do our best to create a prototype using this concept.

Conclusions/action items:

I will continue to research the science behind micro lens arrays and determine whether there is a simpler and cheaper way to create a similar effect of 3-dimensional display as well as depth perception.

2021/10/14 Evidence for Smartphone Practice in Microsrugery

HENRY PLAMONDON - Oct 14, 2021, 7:20 PM CDT

Title: Evidence for Smartphone Practice in Microsurgery

Date: 10/14/2021

Content by: Myself

Present: Myself

Goals: Learn about the evidence for using smartphones for practicing microsurgery

Content:

Title: Microsurgery training with smartphone

Database: Pubmed

IEEE Citation:

C. S. C. A. K. T; "Microsurgery training with smartphone," *Handchirurgie, Mikrochirurgie, plastische Chirurgie : Organ der Deutschsprachigen Arbeitsgemeinschaft fur Handchirurgie : Organ der Deutschsprachigen Arbeitsgemeinschaft fur Mikrochirurgie der Peripheren Nerven und Gefasse : Organ der V...*, 23-Oct-2018. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/30352473/. [Accessed: 15-Oct-2021].

From this article, I learned that using a smartphone for practice in microsurgery has been tested before. However, the difference I noticed between our decisions so far and this teams' decisions is that they used a magnification of 10x. I think this might be a little out of our reach using the iPhone, but I think it would be smart to consider possibly zooming in further than 2x, as this does not give quite the same ability and effect as 10x. This will be useful moving forward with the brainstorming and design process.

Conclusions/action items:

Decide whether or not to increase the amount of zoom/magnification we will use with the iPhone camera.

2021/10/14 Depth Perception in VR

HENRY PLAMONDON - Oct 14, 2021, 8:01 PM CDT

Title: Depth Perception in VR

Date: 10/14/2021

Content by: Myself

Present: Myself

Goals: Better understand some of the complexities of depth perception in VR

Content:

Title: Scaling of compensatory eye movements during translations: virtual versus real depth

IEEE Citation:

Dits J;King WM;van der Steen J; "Scaling of compensatory eye movements during translations: Virtual versus real depth," *Neuroscience*, 29-Aug-2013. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/23639883/. [Accessed: 15-Oct-2021].

This article is specifically helpful as the authors took into consideration the angles at which the eye perceives different wavelengths of light in the virtual reality conditions. They found some differences between the real world and VR, which we will need to consider when creating the hardware necessary for this project. Some of the relevant diagrams are shown below with the angles of eyes and the different light.

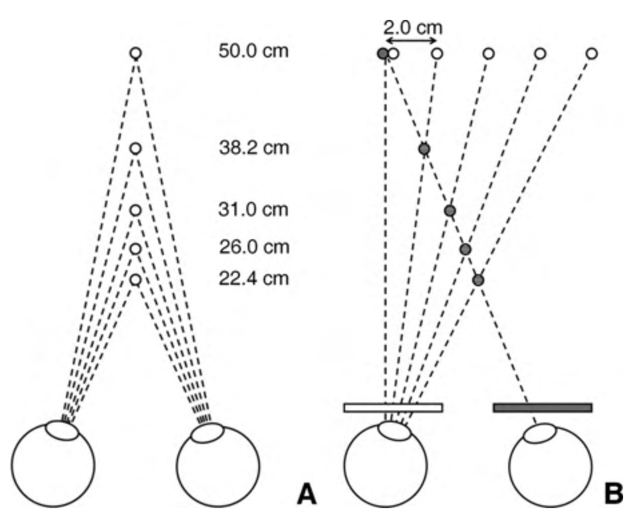


Figure caption from the article:

The two real and virtual target paradigms. Panel A shows the real targets that were located at 5 distances from the subject. Panel B shows the 'virtual targets'; six optic fibre tips (top circles): one green fibre on the left (filled circle) and five red fibres on the right (open circles). These are seen through red and green filters (bottom bars): the left eye could only see the red fibres; the right eye only the green fibre. Only two fibres were switched on at the same time: the green one and one of the red ones. The distance to the intersections of the lines of sight of both eyes (striped circles) was defined as virtual target distance. The target distances of the virtual targets in B matched those of the real targets in A. Note that for the furthest virtual target, the green and red fibre are located at approximately the same position. This target therefore resembles a real target.

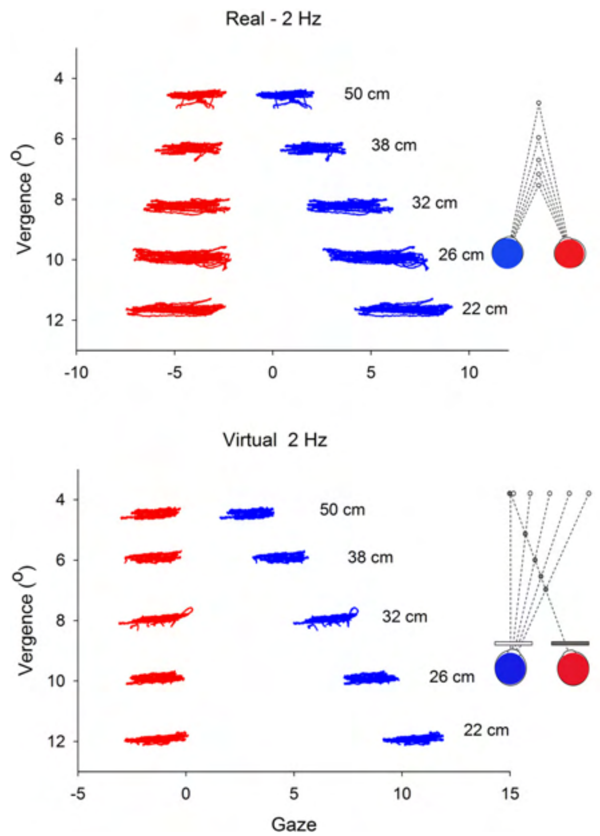


Figure caption from the article:

Gaze versus vergence angle during whole-body translations at 2 Hz. In this plot vergence angle is plotted on the y-axis (zero vergence at top), whereas the gaze positions of the left (blue) and right (red) eyes are plotted on the X-axis. The panel shows that for real targets (upper panel) there is an increase in gaze amplitude and vergence angle as a function of vergence. Gaze trajectories become larger for near viewing distances, consistent with the geometrical requirement for keeping the eyes on target during the linear translations. The lower panel of figure 3 shows as an example a gaze vergence plot of eye movements in response to the targets at all presented virtual distances. For any virtual distance, the gaze amplitude of the right and left eye remained the same regardless of the vergence angle required to fuse the virtual target by shifting the left eye (blue traces) to the right

Conclusions/action items:

This information and these graphs may be useful when considering the viewing angles that the teachers will have when viewing the screen displaying what the trainees are seeing at any given time.

2021/10/19 3D Visualization for Dentistry

HENRY PLAMONDON - Oct 19, 2021, 9:07 PM CDT

Title: Augmented Reality System for Oral Surgeries

Date: 10/19/2021

Content by: Myself

Present: Myself

Goals: Learn how this team used augmented reality for stereoscopic views in oral surgery

Content:

Paper Title: Augmented Reality System for Oral Surgery Using 3D Auto Stereoscopic Visualization

IEEE Citation:

H. H. Tran, H. Suenaga, K. Kuwana, K. Masamune, T. Dohi, S. Nakajima, and H. Liao, Springer-Verlag Berlin Heidelberg 2011, rep., 2011.

This article is very in-depth in their approach to creating stereoscopic imaging in augmented reality. I didn't have time to completely look into all of the details, but they used a software to determine which pixels would show up at different points on the display. This may be slightly too complicated for our timeframe, but it could be helpful upon further review in the future.

Conclusions/action items:

Come back to this article and take more time to read the full science behind their concept. Determine whether or not it is possible to apply this to our prototype.

2021/09/26 Personal VR Design

HENRY PLAMONDON - Oct 19, 2021, 8:05 PM CDT

Title: Personal Preliminary VR Design

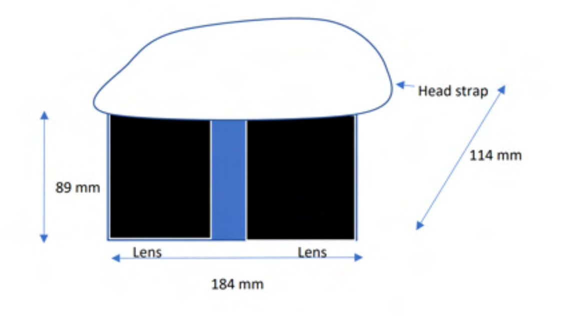
Date: 9/26/2021

Content by: Myself

Present: Myself

Goals: Brainstorm a preliminary design idea

Content:



Virtual Reality Headset for Viewing

WiFi or Bluetooth connection to headset

Figure 1: Preliminary design idea by myself. Basic dimensions for a VR headset and an iPhone 8 are shown.

I had envisioned a virtual reality headset that would be able to connect to the camera of the iPhone using Bluetooth or WiFi. I used some basic dimensions of an Oculus Rift headset to design the virtual reality headset we would be using [2]. This idea was ruled out early in the process of determining a design to continue with as the virtual reality headset would have been too difficult to implement for our purposes and in our timeframe.

[1] Reference for iPhone dimensions picture: https://www.dimensions.com/element/apple-iphone-8-plus-11th-gen-2017

[2] Reference for Oculus Rift Headset: https://newatlas.com/gear-vr-vs-oculus-rift-specs-comparison-2017/49015/

Conclusions/action items:

This design will not be utilized by the team in the future, however, it helps to understand where the boundaries are regarding the difficulty of the problem at hand. Our final design may be able to utilize the techniques that allow for the virtual reality experience.

2021/12/07 Future Product Testing Protocol

HENRY PLAMONDON - Dec 14, 2021, 9:27 PM CST

Title: Future Product Testing Protocol

Date: 12/7/2021

Content by: Mitchell Benyukhis and myself

Present: Mitchell Benyukhis and myself

Goals: Complete a protocol for possible future testing of the prototype for efficacy

Content:

Mitchell and I designed a testing protocol to determine the efficacy of the prototype once it is slightly more refined. The purpose of the testing protocol is to determine whether or not our device is a viable alternative to the current microscope that is used by comparing scores of people who practiced on our prototype to scores of people who practiced on the actual microscope. The scores were based on time and accuracy, as these are the two most important abilities that students need to master when practicing for microsurgery. From my statistics classes, I suggested using sample sizes of 100 people, as this is generally enough to create a bell curve in normally distributed populations. I also helped articulate the statistics "jargon" by taking the protocol shell that Mitchell created and making some adjustments as I saw fit to be more statistically useful. I also made some adjustments to the way in which students were trained and tested. The completed testing protocol is linked below.

Conclusions/action items:

Consider other ways in which our prototype could be tested and possibly use this protocol in future semesters after more revisions are made. Add the testing to the final report and the poster.

HENRY PLAMONDON - Dec 14, 2021, 9:28 PM CST

Overall Test:

- Draw two 2' x 2' boxes side by side on a surgical sheet
- Place 5, 1mm long, sutures in left box
- Students will use tweezers to move sutures from left box to right box
- Time will start when student picks up tweezer
- Time will conclude when student puts down tweezer

Test Simulations 1:

- Collect a simple random sample of 100 first year medical students who are practicing microsurgery and split randomly into groups A and B, 50 students in each
- Both groups can practice the testing procedure using the microscope during normal training hours
- Group A is allowed to use the mirror prototype at home after normal training hours and during the weekend
- Group B is allowed to use no prototype after normal training hours, prior to the test
- After five days of training, the students will return the following week and be tested in the lab
- Allow both groups 3 attempts at the test and take average completion time and number of movements

Analysis 1:

- Record Total time to complete the task
- Record Total hand movements
- Total grade 0-100
  - Time points start at 50, and 1 point is subtracted for every second over 25 seconds
  - Hand movement points start at 50, and 1 point is subtracted for every movement over 16 base movements

Conclusion 1:

- Evaluate the scores using a Student's t-test for population means using a significance value of 0.05
- H_0: Mean value of each student's three scores in group A = mean value of each student's three scores in group B
- H_A: Mean value of each student's three scores in group A ≠ mean value of each student's three scores in group B
- If our p-value for the Student's t-test using the means of each students' three scores is less than or equal to .05, we reject the null hypothesis and can conclude that there is significant statistical evidence that the means of the means of groups A and B are not the same. If the p-value is greater than .05, we have insufficient evidence to reject the

RL_Product_Testing_Protocol.pdf(34.4 KB) - download

2021/12/03 Showing Depth Perception

HENRY PLAMONDON - Dec 14, 2021, 9:44 PM CST

Title: Showing Depth Perception with Prototype

Date: 12/3/2021

Content by: Myself and Kenzie Germanson

Present: Myself and Kenzie Germanson

Goals: Provide a visual representation of depth perception created with our device

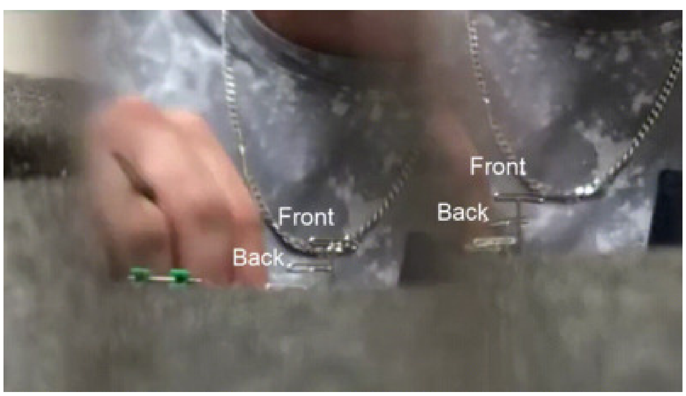
Content:

Kenzie and I created a video showing me moving a small clip away from the camera in small steps to different pins in the foam base. It is clear to see that depth perception is achieved with this video and can be compared directly to a similar video using a single smartphone camera. This helped to give our client an idea of the capabilities of the device as well as potential consumers. This is the driving point of our project, so it's vital that we provide this to validate our design. The video is linked below.

Conclusions/action items:

Continue working on deliverables and put the video in the VR goggles to present to people as they view our project. Continue to improve the quality of videos we take when showing depth perception as this one is at a slight angle from the plan of the pins.

HENRY PLAMONDON - Dec 14, 2021, 9:45 PM CST



Depth_Perception_Video.gif(46.3 MB) - download

2021/10/02 - Depth Perception

KENZIE GERMANSON - Oct 20, 2021, 10:48 AM CDT

Title: Neural basis of depth perception from motion parallax

Date: 2021/10/02

Content by: myself

Present: myself

Goals: gain a better understanding of how the brain perceives depth and how we can use that in our designs

Content:

IEEE:

H. G. R. Kim, D. E. Angelaki, and G. C. DeAngelis, "The neural basis of depth perception from motion parallax," *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, 19-Jun-2016. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4901450/. [Accessed: 02-Oct-2021].

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4901450/

motion parallax - relative motion of objects at different distances

Pictorial depth cues - occlusion size, perspective, shading, texture, gradient, blur - develop 3D scene but not depth

multiple vantage points help create depth

2 eyes being separated provide depth

Motion parallax helps 3D vision but binocular disparity has better precision.

Conclusions/action items:

Apply this information to understand the splitting lens design. This makes the split lens design make sense because it creates the binocular vision internally without 2 lenses.

2021/10/13 Orbeye Cost

KENZIE GERMANSON - Oct 20, 2021, 10:46 AM CDT

Title: Orbeye 3-D system turns surgery into dizzying, immersive experience

Date: 10/13/2021

Content by: myself

Present: myself

Goals: obtain a cost of surgical microscopes

Content:

IEEE:

D. Grady, “Orbeye 3-D system turns surgery into dizzying, immersive experience,” *The Columbus Dispatch*, 12-Jan-2018. [Online]. Available: https://www.dispatch.com/news/20180114/orbeye-3-d-system-turns-surgery-into-dizzying-immersive-experience#:~:text=Mark%20Miller%2C%20a%20spokesman%20for,cost%20about%20%24400%2C000%2C%20Langer%20said. [Accessed: 13-Oct-2021].

https://www.dispatch.com/news/20180114/orbeye-3-d-system-turns-surgery-into-dizzying-immersive-experience#:~:text=Mark%20Miller%2C%20a%20spokesman%20for,cost%20about%20%24400%2C000%2C%20Langer%20said.

"Mark Miller, a spokesman for Olympus, said the Orbeye’s pricing is similar to that of standard surgical microscopes, which range from $200,000 to $1 million. The system that Lenox Hill bought cost about $400,000, Langer said. Other companies are trying to enter the market. "

Conclusions/action items:

Microscopes range from 200k to 1 million, useful information for the report and presentation and also in determining how much cheaper our design can be.

2021/10/19 - iPhone price ranges

KENZIE GERMANSON - Oct 20, 2021, 10:45 AM CDT

Title: iPhone 13 prices

Date: 10/19/2021

Content by: myself

Present: myself

Goals: find current price ranges of recent phones to compare to the microscope cost

Content:

https://www.cnet.com/tech/mobile/the-best-iphone-13-deals-are-here-target-best-buy-verizon-and-more/

IEEE:

D. Starr, “The best iPhone 13 deals are here: Target, best buy, Verizon and more,” *CNET*, 28-Sep-2021. [Online]. Available: https://www.cnet.com/tech/mobile/the-best-iphone-13-deals-are-here-target-best-buy-verizon-and-more/. [Accessed: 19-Oct-2021].

As with previous iPhones, pricing will depend on the model and storage capacity. The cost also does not include activation fees or taxes. US prices for the base models for each are below:

- **iPhone 13** starts at $799
- **iPhone 13 Mini** starts at $699
- **iPhone 13 Pro** starts at $999
- **iPhone 13 Pro Max** starts at $1,099

IPHONE 13 PRICES BY MODEL AND STORAGE CAPACITY

	128GB	256GB	512GB	1TB
iPhone 13	$799	$999	$1,099	N/A
iPhone 13 Mini	$699	$799	$999	N/A
iPhone Pro	$999	$1,099	$1,299	$1,499
iPhone Pro Max	$1,099	$1,199	$1,399	$1,599

Base prices with 128GB of storage range from 800-1000

Conclusions/action items:

Prices of phones are significantly less than a surgical microscope and widely accessible

2021/9/20 Microsurgery basics

KENZIE GERMANSON - Oct 20, 2021, 10:34 AM CDT

Title: Microsurgery

Date: 2021/9/20

Content by: myself

Present: myself

Goals: understand the basics of microsurgery in order to approach the project with baseline knowledge.

Content:

https://www.encyclopedia.com/medicine/divisions-diagnostics-and-procedures/medicine/microsurgery

IEEE:

> "Microsurgery," *Encyclopedia.com*, 23-May-2018. [Online]. Available: https://www.encyclopedia.com/medicine/divisions-diagnostics-and-procedures/medicine/microsurgery. [Accessed: 20-Sep-2021].

Microsurgery can range from ear nose throat, eyes, gynecology, damaged muscles, transplants, and neurosurgery

Microscopes have movable arms to manipulate the surgical site and position

multiple sets of lenses and high-intensity light allow for high-quality viewing

magnification from 5-40x

Sutures range in size but conventional sutures are from .3mm to .07mm while microsurgical sutures are .03mm to .001mm

Conclusions/action items:

This provides a magnification range we should aim for in our design and also how small the sutures are that we'd need to see in our final product. This provides a guideline of base knowledge about microsurgery to start from.

2021/9/23 - Understanding operating microscope

KENZIE GERMANSON - Oct 20, 2021, 10:43 AM CDT

Title: Understanding and caring for an operating microscope

Date: 2021/9/23

Content by: myself

Present: myself

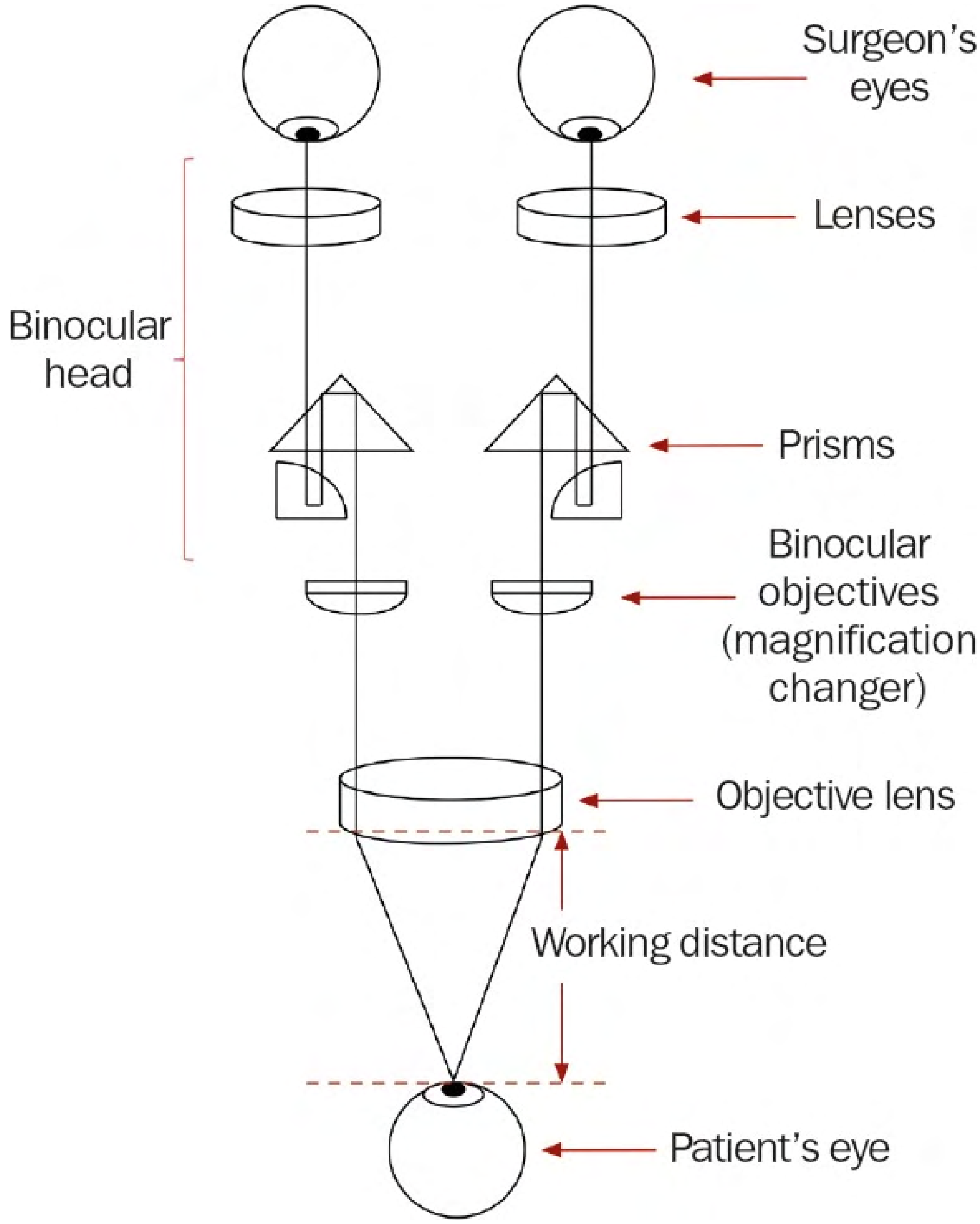
Goals: Understand the inner mechanisms of a microscope

Content:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4069782/

IEEE:

I. Cordero, "Understanding and caring for an operating microscope," *Community eye health*, 2014. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4069782/. [Accessed: 23-Sep-2021].



Conclusions/action items:

Incorporate this information into the PDS that's due tomorrow. This is how microscopes achieve depth - how could that be applied to iphones.

2021/10/01 - VR Capture and Dual lens

KENZIE GERMANSON - Oct 20, 2021, 11:12 AM CDT

Title: VR Capture and Dual lens

Date: 2021/10/01

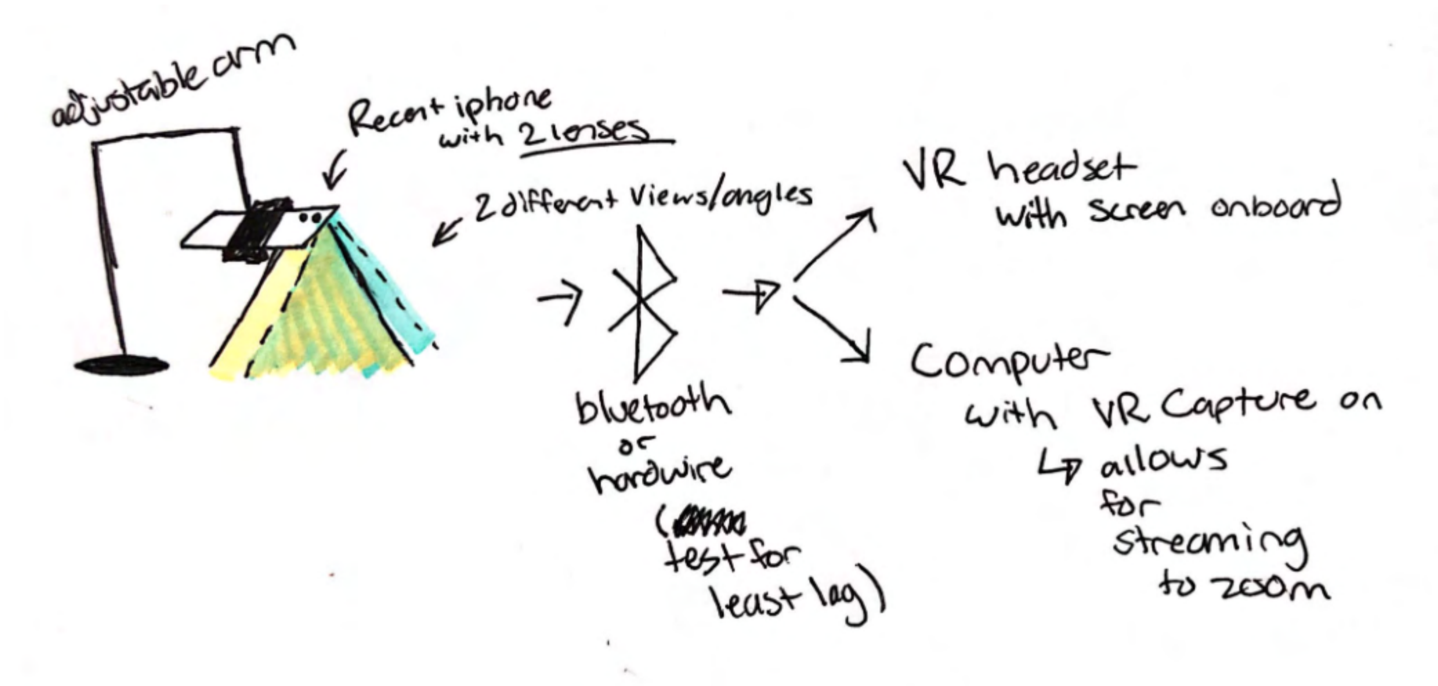
Content by: myself

Present: myself

Goals: develop a preliminary design to obtain the depth of view on an iPhone.

Content:

The color-coded area represents the 2 angles that the different lenses see. Combining those would allow for a deep image. This would be streamed or directly transferred into a VR headset with a screen already on board to limit the need for 2 phones while also streaming it to the laptop where an application called VR capture will combine the image into a streamable view to be able to upload to a zoom meeting and have people watch from anywhere in the world.



Conclusions/action items:

Compare this with other group members design in a design matrix, and narrow that down to a couple of options to present on.

2021/11/21 - Live editing tools

KENZIE GERMANSON - Dec 15, 2021, 10:24 AM CST

Title: Live editing tools

Date: 2021/11/21

Content by: Kenzie Germanson

Present:

Goals: Look for a way to crop a stream from one phone to the headset phone live

Content:

We want to make sure that the video from the recording phone is put into the phone in the headset properly. Some people have been suggesting making a program for it by using last semester's code but I feel like there is probably software out there that would do this.

iMovie would be perfect to edit on for non-live streamed videos - possible use later on for proof of concept.

OBS is a tool a lot of streamers use to edit their videos live, it'd allow us to trim out any blind spots from the lens and adjust positioning. This inherently does have a lot of lag.

https://obsproject.com/

Conclusions/action items:

Decide if we want to go the live route, this would lead to more coding probably because OBS is too laggy. If we wanted proof we could do live regardless of lag this would be a good option. Otherwise, we could avoid live for right now and edit in iMovie or any other basic video editing app.

2021/12/05 - Google Cardboard testing

KENZIE GERMANSON - Dec 15, 2021, 10:26 AM CST

Title: Google Cardboard Testing

Date: 2021/12/05

Content by: Kenzie Germanson

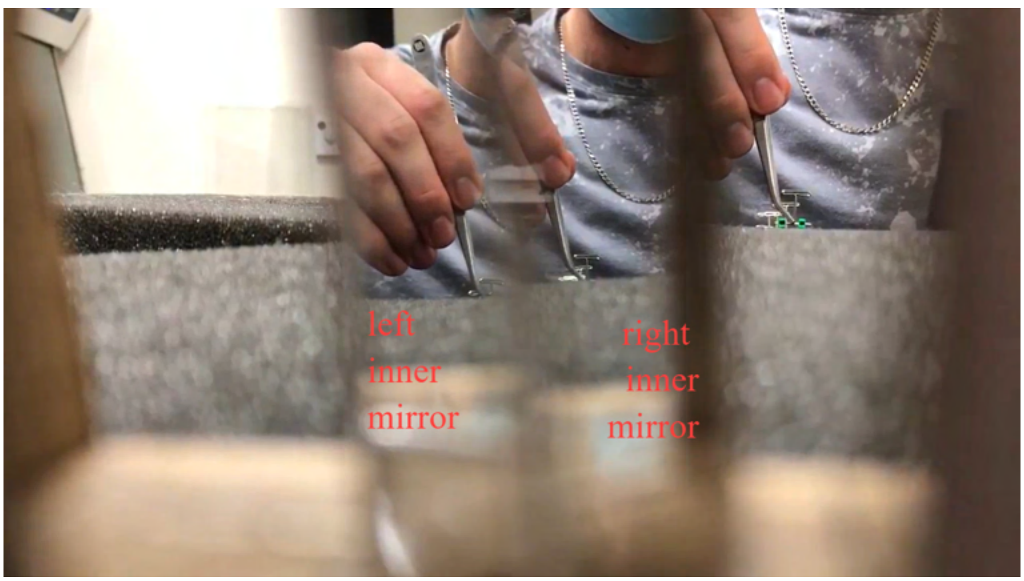
Present:

Goals: look at editing the raw video with the lens attached so it works in the headset.

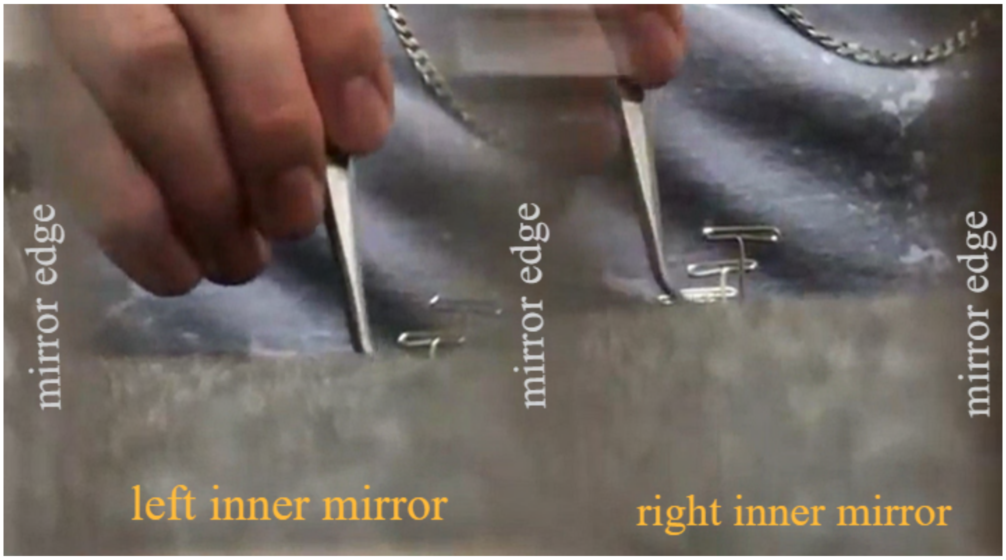
Content:

I started looking at different editing software to edit the video from the lens so it can be viewed live, thinking of putting the video into OBS

It started looking like this:



I decided to zoom it into the inner mirrors - just to see the actual images we want to work with without the background



I thought I would have to edit out the gray spaces where the edges of the mirrors are but found that it looked very similar to how VR video looks typically.

(this is an example of a typical VR video taken from youtube's watch in VR option)

in this example, the images are almost identical, just off by the slightest angle.

More importantly, I noticed that even in this, there is blank space between the two images and on the side of them - similar to our lens video, including the mirror edges.

Putting the lens video straight into the headset worked very well - with no editing.

Conclusions/action items:

Editing the live video doesn't have to be as complex as we are making it out to be. It doesn't need to be edited live, it only needs to be transferred from the recording phone to the headset in some way that isn't full of lag. I'm assuming using a wireless connection will be inherently laggy so finding a way to be hardwired would be immensely better.

2021/12/06 - Proof of 3D vision in VR

KENZIE GERMANSON - Dec 14, 2021, 12:36 PM CST

Title: Proof of 3D vision in Vr

Date: 2-21/12/06

Content by: Kenzie Germanson

Present:

Goals: Make a proof of concept video that the VR headset does make 3D vision.

Content:

Prof. Block told us we have to have a short mp4 where we take 2 images of the same view, turn it into a video, and put it into the headset just to prove the headset works.

Doesn't need to be through the lens, just take a photo.

I took our video without the lens of Henry moving a clip between pins and put it into a VR video-making app that splits the image into two, slightly angled.

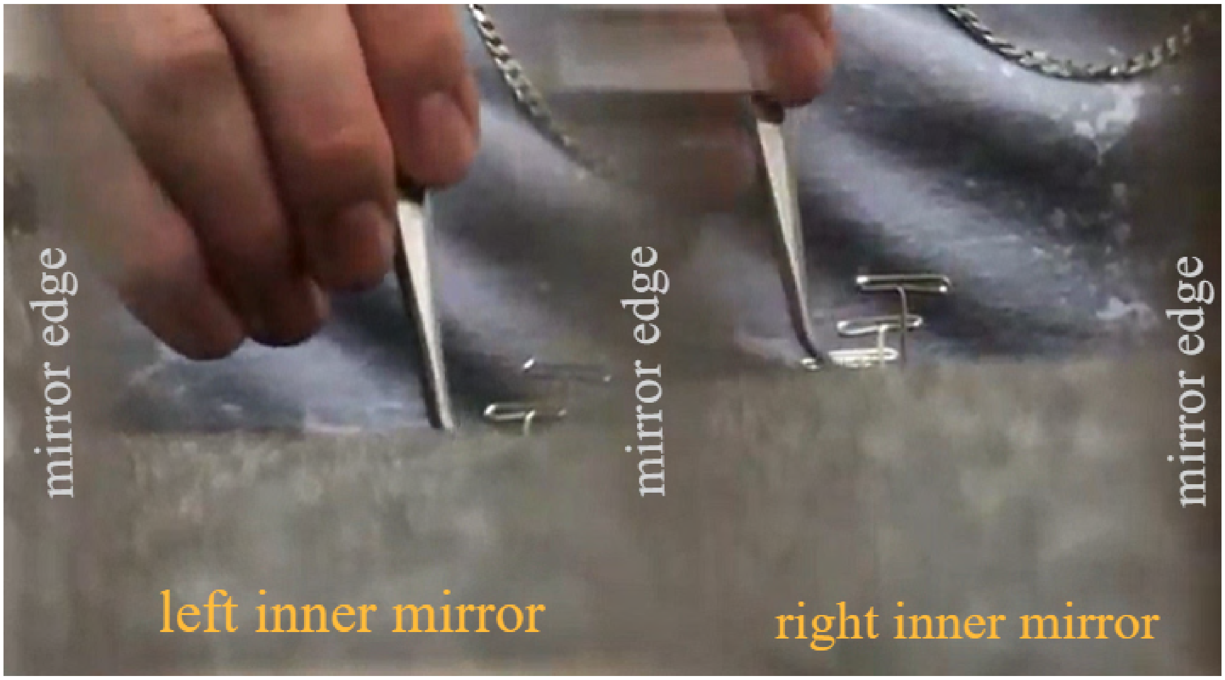
This is what the original video looks like, without the lens or VR editing.

When put into the VR editing app, it looked like this:

(these are all just screenshots from actual videos for the purpose of seeing how the format changes)

when this was put into the VR headset it worked as expected but I noticed that because this app doesn't really get 2 different side views of the same image, it only differently crops them, there really isn't any sense of depth.

So I tried it with the zoomed-in lens video from the previous entry from yesterday.



Found that not only does this video work in the headset, you can also see depth because of the two different angles made in the lens.

Conclusions/action items:

I did more than I thought I would - I only intended to make a simple proof of concept video with the headset but found that I didn't even have to do that, I could just put the lens film straight into the headset and it worked way better than expected. Only positive outcomes came from this testing. This proves that what we've been doing this whole semester actually works and we could really do something with this lens.

I also turned these videos into repeatable gifs for less hassle in the headset (a video you have to rewind and press play every time, gif just repeats the video infinitely)

lens - zoomed - gif

NO lens - gif

Bring cardboard and all supplies to the next meeting to show the team the progress.

2021/10/10 - Learning from Poster Presentation

KENZIE GERMANSON - Dec 14, 2021, 12:55 PM CST

Title: Learning from poster presentation

Date: 2021/10/10

Content by: Kenzie Germanson

Present: Whole team (minus Nicholas because covid)

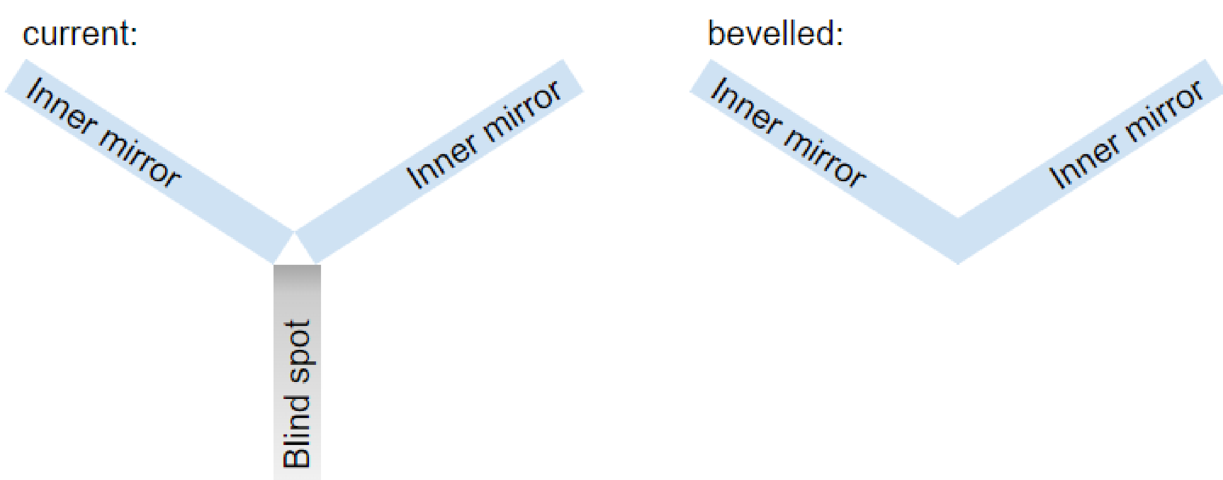
Goals: Get feedback on future work.

Content:

Some people came up to our poster and gave some good ideas on how we could improve this in the future

One student suggested going off of our 3D printing the housing idea, that because we don't have the most concrete angles, and probably need the angles to be adjustable per user anyway, you could print the housing with tiny holes in the base of the box. You would then use the metal pins we've been using in testing, attach them to the back of the mirrors, with a small amount of the pin sticking out the bottom. Then pop the mirrors in place into the holes of the box. This way, you could make sure that the mirrors wouldn't become weirdly angled from top to bottom (we need them completely vertical), and also the housing would be more secure so that the mirrors won't move. However, because they are in a pinned spot, they can still rotate on their axis. Once the user gets the mirrors in the angle they want they can just put a dot of super glue at the base and they won't move. Ideally, there would be some rotating and locking mechanism on each mirror but the super glue would be a starter.

Another student suggested we bevel the edges of the inner mirrors so that they fit flush together. This would eliminate any blind spot in the middle. While that blind spot in the middle is a good separator between the two images, as shown in the Google Cardboard 12/5 entry, it is also caused some blurriness in the image when it is put into the headset because it is not a solid line, it blurs into the mirror's reflection. If you bevel the inner edges of the inner mirrors then instead of two corners coming together in the middle, they would be flush together and go from one mirror directly into the next.



I'm not entirely sure if this idea would actually remove the blind spot in the middle but it is definitely worth trying out.

Conclusions/action items:

These are all very good ideas that I think would be worth implementing. Now that we know we have a functioning prototype with a promise of a future, it's probably safe to get more creative with cutting the mirrors and 3D printing. It wouldn't be a complete waste of materials because we know each trial would improve the design that we know functions. Previously we didn't know that we were even going down the right path so it didn't make sense to waste a bunch of materials. Now I think trying both of these options would be well worth the time and resources.

2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.

2014/11/03-Template

MITCHELL BENYUKHIS (benyukhis@wisc.edu) - Oct 19, 2021, 6:22 PM CDT

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items: