BME Design-Fall 2019 - Kurt Vanderheyden
Complete Notebook

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Table of Contents

Team contact Information

▪ RILEY PIEPER ▪ Sep 18, 2019 @06:44 PM CDT

Last Name	First Name	Role	E-mail	Phone	Office Room/Building
Rogers	Jeremy	Advisor	jdrogers5@wisc.edu		3142 ECB
Suminski	Aaron	Client	suminski@neurosurgery.wisc.edu		9430 WIMR
Sajdak	Ben	Client	bsajdak@wisc.edu		9430 WIMR
Vanderheyden	Kurt	Leader	kvanderheyde@wisc.edu	9203214965	
Schmidt	Kyle	Communicator	kjschmidt9@wisc.edu	9207334733	
Pieper	Riley	BSAC	rgpieper@wisc.edu	6306056455	
Tan	Kevin	BWIG	kktan2@wisc.edu	6083349375	
Thole	Nolan	BPAG	nthole@wisc.edu	6085759595	

Project description

▪ RILEY PIEPER ▪ Sep 18, 2019 @07:16 PM CDT

Course Number: BME 200/300

Project Name: Rodent Rotation and Translation Stage

Short Name: RRaTS

Project description/problem statement:

Research of mammalian retinal photoreceptors, conducted via the imaging of rodent model organisms, requires precise alignment of the specimen. A device providing facile alignment of rodent eyes within the imaging system's field of view as well as rotational freedom for accessibility to a holistic view is called for. This device must provide at least 2 rotational degrees of freedom, pitch and yaw, as well as 3 translational degrees of freedom for the positioning of the eye at the intersection of the rotational axes.

About the client:

Dr. Rogers is a professor in biomedical engineering at the University of Wisconsin - Madison. He primarily works in the field of imaging with a specific interest in developing optical techniques for the imaging of eyes and retinal tissue.

9/18/2019 Meeting 1

▪ RILEY PIEPER ▪ Sep 18, 2019 @09:56 AM CDT

Title: Client Meeting 1

Date: 9/18/2019

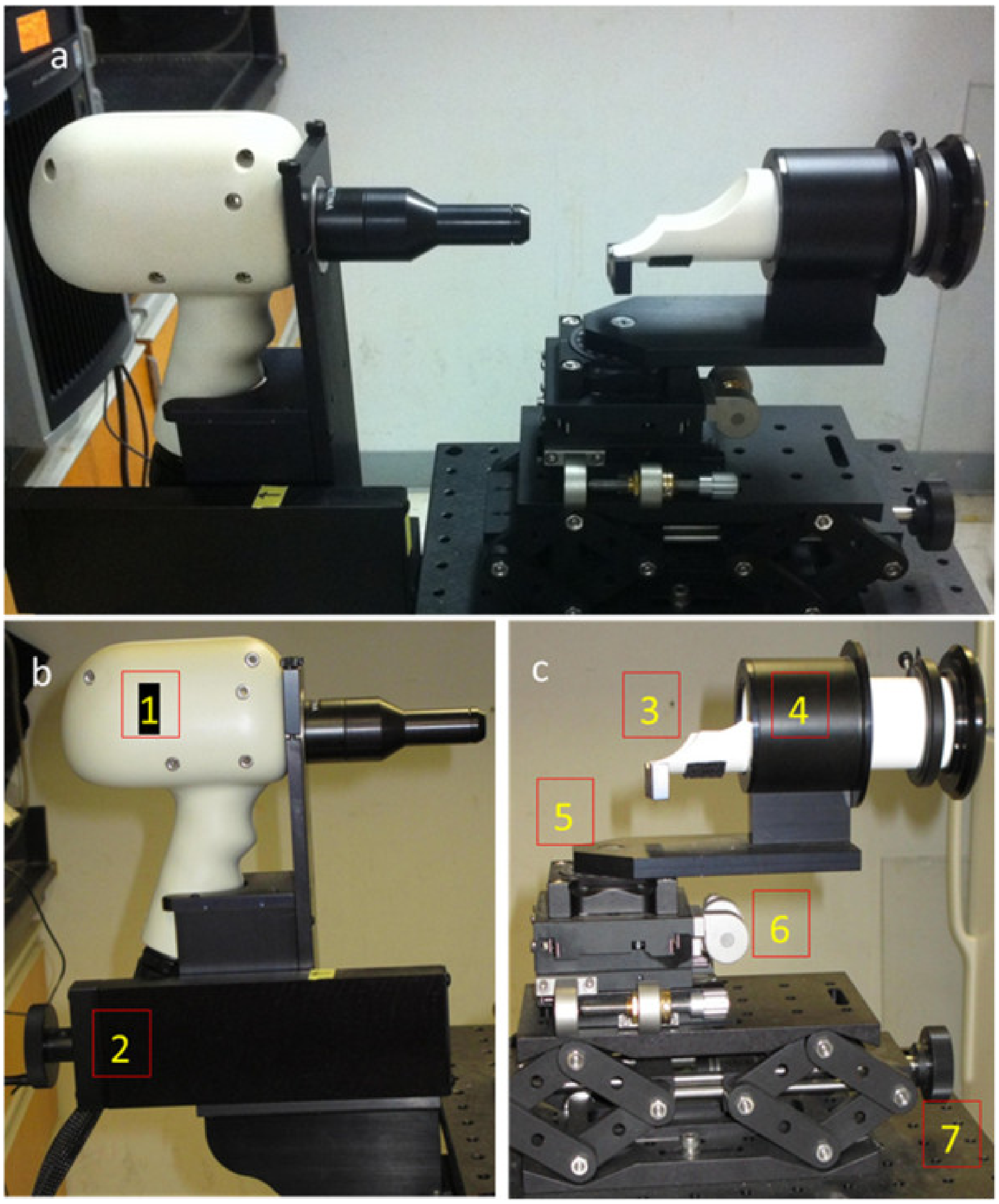
Content by: Riley Pieper

Present: Full Team

Goals: Connect with the clients to introduce ourselves and meet them. Hear more from them about the specific problem they are trying to design and what they are looking for in a design. Learn about the client's thoughts on the previous design in terms of what was successful and what can be improved upon. Discuss expectations for future client meetings.

Content:

- Bioptigen - a product that does something similar
    - RAS: rodent alignment system



- building adaptive optics - a tool to image cells in the retina (humans and animals)
- eventually help to do cell replacement therapy or gene therapy
    - diagnostics

        - tracking therapies
        - developing therapies
- general problem: trying to image things, you need a way to move them around
    - microscope stage has slides that can translate in the plane
    - some imaging systems can move around the animal
- in this case: imaging system is huge and won't be moveable: need to be able to move the animal
- want to look at different regions of the retina: the ability to rotate
- 6 degrees of freedom
    - pitch
    - roll
    - yaw
    - three translational degrees
    - not all are necessary for imaging
        - at least 2 degrees of rotational freedom: pitch and yaw most important (roll just rotates the image)
- alignment of the coordinates of the degrees of freedom is critical
    - position animal such that the pupil is at the center of rotation
        - this is where the translational DOF come into play
- would like various holders that are swappable
    - one for a mouse
    - one for a rat
    - one for tissue samples
    - opens up a lot of applications - a number of collaborators could alignment system for imaging
        - fairly widespread demand for this project design
- last year:
    - swappable platforms (magnetically attached)
    - accuracy/precision: doesn't need to be a micrometer stage
    - other needs:
        - a place for isofluorane cone to come in (can send pictures to help out with them)
        - think very broadly about various ways to solve this problem
        - need to be able to clean everything working with animals
            - smooth surfaces without crevices
            - ability to autoclave
            - gearing makes it harder to clean
        - like the fact that the RAS design has enough friction to hold it in place but moveable when necessary
            - makes for a smooth surface that is easy to clean
        - translational DOF doesn't need high precision - just need to be able to center the pupil
            - 100 microns
        - would like more precision via the rotation
            - would like within 1/10th of the field of review
            - can give us a specific number for precision
        - at a minimum want two DOF of rotation
- gimble mount - allows the intersection of the axes
- particularly like the fact that the area near the head of the rodent is open - necessary for imaging and anesthesiology
- almost need 9 DOF
    - three translation to move the animal so the eye is at the center of the rotation axes
    - three translation to move the whole system to be aligned with the imaging system
        - some of the DOF could even be the 'cart' used the move the system into position
- Ben will be in contact: has done a lot of imaging - good contact for first-hand experience resource
    - will be the primary contact for this
- the previous team only meet the client twice: would like to meet more often (communication is key)
- ideally, make the design freely available to use (get credit for it) as opposed to money
    - getting it protected is important if it will ever see the light of day (FDA approval)
- specimen holder:
    - straight line makes more sense (symmetric)
    - the cutaway area where warming blanket could lay
    - scalable for rats and mice
    - times when they actually get the eyeball itself (use the same holder to put a 'globe' (just an eye))
    - ability to come in and add eye drops so it doesn't dry out
    - accessibility for isoflurane cone (anesthesia)
    - no separate mechanism for holding the eye open
- break between the degrees of freedom and the holder itself (a swappable attachment that can be redesigned for future need)
- budget: $350
    - however, if we identify there is a critical component that goes over budget, we can talk about it

    - low cost is ideal, but priority is to solve this problem
- print things when it makes sense to (prototype)
    - could also get materials for machining
        - just need to get names associated with his account to get things printed at the MakerSpace
- ideas:
    - two concentric spheres (alike the concentric cylinders of RAS)
    - gimble - goes back to the days of compasses on a ship (gyroscope)

Conclusions/action items: We will use the information that was communicated in this meeting and documented here to begin focused research related to the design expectations of the client. We use the information conveyed here to develop our initial product design specifications (PDS) that will be completed before 9/20 (this Friday). As the design begins to be hashed out and communications remain open with the client, the PDS may change throughout the project process. Immediately moving forward, the team will conduct research specifically relating to the competing design noted during this meeting (the RAS) and learn about any intellectual property that has been patented relating to it. Based on the fact that our client vocalized an interest in maintaining clear communication and meeting throughout the semester, the team will plan a second client meeting within the next two or three weeks, especially once the team has compiled a design matrix of design ideas that could be moved forward with.

10/2/2019 Meeting 2

▪ RILEY PIEPER ▪ Oct 02, 2019 @10:02 AM CDT

Title: Client Meeting 2

Date: 10/2/2019

Content by: Riley Pieper

Present: Kurt Vanderheyden, Nolan Thole, Kyle Schmidt

Goals: Clarify some of the specifications, specifically related to the precision requirements of the translation/rotation. Also share some of our preliminary design ideas with the client to recieve feedback or learn some new ideas that they may have.

Content:

- speaker from Berkeley does adaptive optics
    - use a contact lens that the eye is positioned to lined up with the imaging beam
- Precision Requirements
    - Internal XYZ
        - need the center of rotation to be about the pupil
            - the iris is further in that it appears to be
            - a pupil is an image of a hole
        - 100 micrometers
        - the pupil itself will be about 1 mm
        - rodents move (breathing) while they move
        - 50 mm of XYZ of positioning within the rotational components
    - External XYZ
        - 100 micrometer
    - Rotational
        - target being able to navigate +/- 30 degrees in any rotational axis
        - degree of precision is watching in the camera and adjusting to see different portions of the retina
        - need rotation to be smooth - stays put once rotation is found
            - simple is better
        - focal length in a mouse eye is 2 mm
        - resolution to attain is 1 micron - 500 micron FOV
        - ability to position with an accuracy of 2 degrees
        - feedback measurement (micrometer or visual field) allows adjuster to achieve a high degree of accuracy
- another way to think about the design:
    - center of rotation is fixed to the point necessary for the instrument
        - not necessarily adjustable of the whole design
- hexpod platform

- be able to flip the position of the animal 180 degrees to switch to the other eye
- design of Translational DOF internal

    - can use friction if smooth enough
- 'cart' to carry and move the device will likely NOT be on the actual optical table - off the side (from the ground)
    - SIZE is not an issue

Conclusions/action items: Implement these ideas into our developing designs as we continue to develop our preliminary designs to be evaluated in our design matrix in the next two days to be presented on Friday at our preliminary design presentation. Our client will be present at our presentation. Furthermore, the team will update our project design specifications with the new information provided in this client meeting. As the client continues to show interest in keeping close contact throughout the semester, we will plan on scheduling another meeting within the next couple weeks. As we ran out of time in this meeting to share design ideas that we have drawn up, we will present these to our client during our preliminary design presentation and potentially connect with them after if they have any questions or concerns.

10/9/2019 Meeting 3

▪ RILEY PIEPER ▪ Oct 09, 2019 @09:53 AM CDT

Title: Client Meeting 3

Date: 10/9/2019

Content by: Riley Pieper

Present: Kurt Vanderheyden, Kyle Schmidt, Nolan Thole

Goals: Connect with our client to debrief following our preliminary presentation and finally discuss some of our preliminary design ideas as well as the Pizza design that we have initially decided to move forward with. Askt the clients questions that have arisen when drafting the preliminary report.

Content:

- use a contact that could position the pupil at the center of the axes of rotation
- laser sight could add unnecessary complexity and cost
    - simpler the better for this design
    - won't add a significant amount of functionality
    - could always be added later
    - don't prioritize
- contact lens would be aligned/connected to the imaging device
- may be ready by the end of the semester to do some testing here
- testing
    - setting up some intersecting laser pointers (see with notecard)
- hexapod stage
    - position with the multiple actuators
    - all of the DOF are coupled
    - could we 'turn off' the internal translation DOF and leave he rotation?
        - this is the concept that we are aiming for
- xyz gets the eye at the center of rotation and wheel the rotating device up on a cart
    - good to be mechanically decoupled on a cart because the breathing of the animal would introduce vibrations to the imaging device
    - precision of cart would be sufficient
- drawbacks of Bioptigen RAS design
    - different species size limits the use of the holding cylinder
    - in/out of the tube allows the head to be over the pivoting point
    - the eye is never at the center of the rotational axes (the pitch always changes the translation of the eye)
- tube design pros:
    - stability
        - reduce vibrations
- design review
    - Bowls
        - pros:
            - stability
        - issues:
            - how sturdy is the post in the middle
            - don't need the bowls (can just use 'arms' alike a gimble)
            - don't necessarily need
        - ideas:
            - eliminate the points of rotation and keep the frictional contact between concentric bowls
            - alike a microscope slide - not precise movements
            - 'unconstrained'
            - how would the rotation be locked with this idea?
    - Field Goal
        - pros:
            - open - a lot of access
        - concerns:
            - stability - things hanging out would be susceptible to vibrations
    - Pizza
        - dont necessarily need the threaded rods and the precise dials

        - could just use friction to move these elements
- overcomplication is a general concern
    - any threaded element adds nooks and crannies that are difficult to sanitize
    - being able to wipe the design down is a key component - SMOOTH SURFACES
- when putting things together: get a lot out of trying things out with scissors and cardboard
- materials for the final design:
    - autoclavability: metal material (machined)
        - much more expensive and time-consuming
    - plastic/PVC tubing would be a reasonable starting point
    - 3D printing is good for certain components
    - KEY: materials that are simple/easy to obtain and machine
        - allow for future use and creation of our design
        - not a priority but something to consider
    - tubing out of PVC
    - the more rigid the better
    - the less porous the better
        - don't want them to absorb water
    - not soluble in ethanol
    - bleach resistant
    - corrosion/rust resistant
    - research: environment conditions of an autoclave
- anything from the hexapod design that can be used in this design?
- Pizza design only needs two internal translation DOF because the cylinder can be slid across the concentric cylinder
- confirm that the Bioptigen RAS system is no longer available - contact the company
    - can be put in touch with a guy that would know if that is the case
- purchasing
    - MDS is the easiest (but its a bad system)
        - can send part numbers to client
    - reimbursements are difficult
    - could potentially use a card at an Ace Hardware
    - best to have a client order the parts for us
    - 3D printing: client may still have active account at the Makerspace
        - can charge to the client's research account

Conclusions/action items: Based on the client's input, it seems that the Pizza design and its building off of the Bioptigen RAS design is a step in the right direction. They have continued to emphasize the need for smooth surfaces and simplicity for ease of sterilization, fabrication, and cost, explaining that entirely manual, friction based adjustment may action be preferrable over dial and thread based adjustment. We also discussed some of the material considerations that the team will begin to think about as we move towards fabrication in the near future. As this period nears, the team will continue to update the design to optimize its outcome and meet the evolving needs of the client. Because this meeting occured so near to the due date of the preliminary report, things discussed in this meeting and documented here may not entirely be present in the report. One key action item is to confirm that Bioptigen no longer sells the RAS design, leaving a significant market gap for the design that we are working on. A future meeting with the client will likely be scheduled once prototyping has commenced.

11/13/2019 Meeting 4

▪ RILEY PIEPER ▪ Nov 13, 2019 @02:19 PM CST

Title: Client Meeting 4

Date: 11/13/2019

Content by: Riley Pieper

Present: Full Team

Goals: Present the 3D printed prototype to Dr. Rodgers and Sajdek to receive their input about how the parts look and fit together. Get their input on the materials and fabrication methods that could be used to create a full-sized design to complete the project.

Content:

- might end up with a contact lens
    - something that is a part of the instrument
- use steel rods to have a high degree of precision on the internal translation
- consider how to build strength in the protruding rods of the internal stage
    - will add a significant moment to think about
    - rodents will weight at extreme 500 grams (about 1 lb)
    - most animals would be 30 but need the flexibility
- could potentially just hold one of the rods to threaded or lockable
- refine specifications
    - ability to move manually with some friction in the three degrees
        - can always shift the animal around on the bed grossly
        - range of motion necessary might not need to be super high
    - would like to have the base of the design was fixed to the instrument
        - cart may not move significantly
        - could be on the client's implementation of the design
    - the bed to hold the specimens may be able to be on the clients
- use materials that are already easily accessible (PVC)
- change the arc to optimize support
    - large near the back of the cylinder
    - narrow near the front
    - mechanically stable
- cut a hole in the back of the design for a temperature probe
- could cut down the height of the back of the internal cylinder
- materials/fabrication
    - PVC is a good option
    - ABS - issues in terms of mounts for an animal?
    - acrylic
    - PMMA - very biocompatible
        - biocompatibility is not a significant concern
    - ARE MATERIALS WIPABLE BY ALCOHOL ETC
    - some components (rods) might need to be strong and metal
    - others can be plastics
    - well placed materials that are hard to clear are an option
    - AUTOCLAVABLE?
        - still minimize the threaded components
        - NOT a hard requirement
- rodents excrete frequently so it will make the holder nasty and need to be sterilizable
- testing
    - might not be able to actually test a rat
        - not very necessary
    - could use a stuffed animal/rubber rats to demo something that is close
        - use something that is 'cute'
    - use a system to test
    - **quantitative testing**
        - **set up a cell phone camera**
        - **put an animal with the eye and align it**

        - **move the rotation and take a series of images to quantify the movement of the pupil as rotation occurs**
    - have multiple tests
        - measure sag on the rods with varying weight
        - doesn't matter what the answer is - just good to know
- check/x design requirements
    - failing to meet them does not fail the project - informs the next iteration
    - stabilizability - autoclavability?
- THORLABS ER6-P4 - steel rods for internal translation
- ordering parts:
    - guest login for Shop@UW
        - easiest to use if findable
        - if can't find - use Amazon
            - must document that it is not on Amazon
    - Grainger and other vendors go through the website
    - ThorLabs order on a credit card
    - SEND CLIENT A LINK TO THE PART AND HE WILL ORDER IT
- heterogeneous design - parts that are easy to the machine are machined and others can be printed

Conclusions/action items: In the days immediately following this meeting, the team will convene to pick the materials and components to be ordered, according, in part, to the input from the client, and send these components to the client for ordering. The SolidWorks drawing of the design will be updated according to the clients' suggestions and the points learned from holding the physical model of the design. The team will also begin to consider some of the testing procedures, specifically the one including the cell phone camera, in order to validate the final design according to the initial specifications for the final presentation.

9/13/2019 Meeting 1

▪ RILEY PIEPER ▪ Sep 13, 2019 @02:24 PM CDT

Title: Week 1 Advisor Meeting

Date: 9/13/2019

Content by: Riley Pieper

Present: Full Team

Goals: Update advisor on initial progress and team activity. Share plan for project schedule moving forward. Learn from our advisor about the project and any advice that he has for our team.

Content:

- talk to Dr. Rogers about where to move from the previous semester's work on the design
- previous work:
    - great job getting some of the dimensions but room for improvement
    - contact the previous group for Solidworks designs
    - fitting under a microscope (previous was large)
- the task this week:
    - talk to Dr. Rogers and learn the direction he wants us to go (he's an engineer)
    - translate convo to an engineering problem that we want to solve
        - PDS - allow to live/breath and change throughout the semester
        - Design specifications
            - quantifiable and testable
            - say with strong words what our device should do at the end and whether those were met
            - testing will show whether we met those specifications (tailor with testing in mind)
- project is SolidWorks centric
- think about how resources and abilities can be divided among things that need to be done
    - start working on a preliminary presentation while Solidworks is being conducted by other members
- spread the work out to alleviate the load throughout the semester
- use the notebooks actively
    - enter ideas that come to us
    - write things done and transfer them to the notebook
    - biggest individual contribution to the class
    - even if doing a literature search and finding nothing
        - what did we search
        - where did we go
        - what will we do next time
- project doesnt need to be the overall product
    - can be a more specific element of it - write PDS accordingly

Conclusions/action items: Meet with our client to learn about the ideas that he has for our project and any thoughts that he has about the previous work that has been done on it. Develop our PDS based on quantifiable and testable metrics, keeping long-term ideas for the type of testing that we *will* do in mind. All team members should also begin conducting research (may be difficult before we meet with our client) on aspects of the project (biomechanics and physiology of rodent imaging). We will also document any ideas that we have related to the design as they come to us for use in the next phase of the project (developing the design matrix and presenting our preliminary work).

9/20/2019 Meeting 2

▪ RILEY PIEPER ▪ Sep 20, 2019 @01:10 PM CDT

Title: Week 2 Advisor Meeting

Date: 9/20/2019

Content by: Riley Pieper

Present: Full Team

Goals: Update our advisor on our group activities this week, specifically concerning our meeting with our client. Discuss the PDS that was recently turned in and hear about any improvements that could be made.

Content:

- use the logbooks - the only way of individually assessing
    - advisor sees the date at which they are entered
- grading
    - grade preliminary things the way we will ultimately be graded on final items
    - want us to clearly know our expectations on our final report/presentation
    - preliminary things are not worth as much
    - class is curved to an AB
- PDS
    - translate the 100-micron error to rotational precision
    - bullet/list the 5 DOF and list the accuracy of each DOF
        - could be different for each
    - what space does the device need to fit into?
    - size or weight of specimen that could be held by the sample holder
    - testing
        - precision
        - weight held
    - center of the eye should be repeatedly placed within a certain precision of intersection of rotational axes
- just the criteria for the design matrix is due next week - explain each criterion
- week following (Oct 4) is preliminary presentations
- resources for how training advisors for grading is done - website has forms used for evaluating our work
- research ideas
    - does the size of the eye or retina by the species determine the *amount* that it will need to translate to image it
    - why Dr. Rogers does the research that he does
        - what diseases are we thinking about
        - why is it important to image the retina
            - social impact etc
            - what benefit does this design have
    - eye physiology
    - motivate why its important to have this design
        - articulate the need and why its not met by current products

Conclusions/action items: Update the PDS to further specify the precision requirements, specifically relating to each individual degree of freedom. Consider the precision of the rotational adjustments and specify these. The PDS will continue to evolve throughout the semester, especially once the development of a specific design begins. The team will continue to update this document to align with the expectations of our client, our advisor, and team members. Moving forward, all team members will continue conducting research with specific interest in the motivation behind the design. This coming week, each team member will brainstorm and develop a rough idea for a design individually. Later this week, the team will meet to share ideas and potentially develop new design ideas together. We will also come to a consensus on the design matrix criteria that will be due to our advisor next week. With the preliminary presentations not far behind, the team will begin outlining what we are interested in presenting on and begin adding components to this presentation.

9/27/2019 Meeting 3

▪ RILEY PIEPER ▪ Sep 27, 2019 @01:28 PM CDT

Title: Advisor Meeting 3

Date: 9/27/2019

Content by: Riley Pieper

Present: Full Team

Goals: Update our advisor on the work we have done in the past week; specifically talk about the design matrix criteria that we put together and ways to improve the criteria to rank the designs that we come up with.

Content:

- Design matrix criteria
    - like how we created the criteria and talked about what the important parts of criteria are
    - relate nicely with our PDS
    - maybe the rotational degrees of freedom isn't important anymore
        - only improve upon the elements that are important to the client for the future
- building off of the previous year
    - don't have to go away from the rotational aspects of the previous design
    - address why the previous design wasn't sufficient
        - if the rotational pieces were sufficient - keep those and improve the other elements
    - weren't satisfied with the ability to put the eye at the center of the rotational axes
        - this is the basis of the design project
        - potentially only change the important component of the design (internal translation)
            - present only on this in our preliminary presentation - design matrix
- presentation
    - background
        - physiology
        - why Dr. Rogers studies these things
        - background on the pros and cons of previous design
            - what the client was happy about and what the client wants us to improve about it
- refining the aspects that fell short
- invite both Dr. Rogers and Ben to the preliminary presentation
- ranking our designs according to our criteria
    - give our designs scores according to each criteria
    - if not seeing a big differentiation between the designs:
        - bunch of good designs
        - criteria are not correct
    - ease of fabrication is usually a big differentiator
- slight redesign of the rotational components to eliminate the crevices of the gears (serializability)
- during the pitch of the individual designs - have design matrix criteria in front of us and evaluate as we share
- can add criteria to make more sense or better differentiate the designs
- make sure the criteria aren't sensitive to the decision taking place
- evaluate the rotational components and translational components separately
    - criteria talking about the integration of the design and how it integrates with the other element
- can meet again or reach out to advisor within the next week if need help
    - can send him the slides to look at
- start working through the preliminary presentation *early*
- if media will be a component of our project, share the media separately than the presentation so that it all works

Conclusions/action items: The team will continue compiling design ideas individually and present them to one another when we meet on Tuesday. Upon meeting, we will discuss the pros and cons to each design, keeping the design matrix criteria in mind. As we evaluate the designs, we will alter the design matrix criteria such that they do a good job of differentiating the designs. The team will consider compiling ideas for the rotational and translational elements separately and evaluating them as such. Furthermore, the team has scheduled a meeting with our client on Wednesday morning to present the design ideas that we have and receive feedback to make changes prior to our preliminary presentation. From this point until next week, we will begin working on the preliminary presentation that will be presented next week on Friday. Our communicator will make sure to email our client(s) the time and location of the preliminary presentation and invite them if they would like to attend.

10/11/2019 Meeting 4

▪ RILEY PIEPER ▪ Oct 11, 2019 @01:18 PM CDT

Title: Advisor Meeting 4

Date: 10/11/2019

Content by: Riley Pieper

Present: Full team

Goals: Debrief with our advisor following the preliminary presentation last week and submission of our preliminary deliverables on Wednesday. Hear his thoughts and ideas relating to our designs presented to him and clarify any questions he may have. Communicate our plans for the next steps in terms of fabrication and testing.

Content:

- this point in the semester: time to 'do'
- next thing coming: show and tell - 8th of November
- the preliminary presentation was good
- client meeting
    - simplify the pizza design
    - our job is to take what our client is telling us and figure out what we can give to them
        - sometimes not always feasible
        - meet criteria that they are talking about
- friction-based adjustment methods
    - can we put the microscope into the loop in terms of testing?
    - spheres/bowls design: dont want to 3d print so how are we going to fabricate?
        - might be stuck with 3d printing something
- do we need to start with something that is as large as necessary?
    - scale down for something that is proof of concept
    - makerspace has a strategist and a much better 3d printer
        - could we get into the ballpark using this machine?
- take what Dr. Rogers said and figure out what the best thing we can do to give him what he needs
    - he knows what he wants
    - if he knew exactly how to do it, he wouldn't have submitted it as a project
- can still test precision with respect to manual manipulation of the stage
    - come up with a coordinate system with respect to the microscope
    - measure bias in how far from perfect position we are able to get
- the problem we need to solve: how do we figure out, in any device, where the center of rotation is
    - we need to figure out where the point is
    - we need to figure out how to get the sample to this point in space
- love the idea of start playing around with cardboard to see if things can start coming together
- suggest: don't feel like everyone needs to be working on the same thing at the same time
- encourage us to set a deadline for when we need to come up with exactly what we are doing
    - take next week to figure out what problem we are going to tackle
    - how do we move forward in this way
- **something that we can push through/retract to the point in space**
    - must always be orthogonal to the eye
    - can we use lasers?
        - mirrors could bend the light
- bowl design is interesting
    - reasonable to understand where the center of rotation would be
- agree with Dr. Rogers: how we bring the eye to the center of rotation and move device can be manual
- disagree with the by-hand rotational adjustment
    - could be implement some mechanical component
    - robotic/automated?
- don't talk to him all the time - get his feedback as necessary
    - meet with him once we know what and why we are going to do
        - looking for approval at that time

Conclusions/action items: At this point, the team needs to develop a plan for how we are going to move forward both in terms of activities necessary (fabrication, materials, etc) and decididing upon a specific design direction. Along these lines, we need to consider the feedback provided by the advisor and clients to determine what the client is looking for and how to best meet these requirements. As it seems that the main goal of this design project is the location of and positioning at the center of the rotational axes, the team must brainstorm how to accomplish this and draw up additions to the exisiting design that include elements that allow for this. With the next event being the show and tell, the team will soon begin fabricating a scaled-down proof-of-concept version of a design (likely via 3d printing or cardboard) to determine how the design fits together. By the end of the semester, it is our goal to develop and fabricate a full-scale version of a working design, but if this does not happen prior to show and tell, the team will use the proof-of-concept as our working design.

10/18/2019 Meeting 5

▪ RILEY PIEPER ▪ Oct 18, 2019 @01:22 PM CDT

Title: Advisor Meeting 5

Date: 10/18/2019

Content by: Riley Pieper

Present: Kevin Tan and Kyle Schmidt

Goals: Discuss our (albeit limited) progress this week, specifically relating to the direction that we have determined to take moving forward. We will discuss action plans for the near future. We will also share our ideas for new elements of the design.

Content:

- 'Testing' - mental testing done to determine the benefit between the designs
    - think about scale - way to express that one design is better than another
    - Bowls need to be twice as large as the pizza cylinder design (the length of the animal)
- could write up a TEST PROTOCOL to work towards the size specification of the design
- is the cart a part of the design? how do we make sure the cart stays in the same place
    - talk to client about the precision of the cart to be used
    - communicate that two of the translational DOF are with the cart that they are using
        - sufficient or include the cart in the design? ASK THE CLIENT
- friction-based materials for fixing elements in place
    - 'magnetic stands with permenant magnets
        - turning nob engages/disengages a magnet (hold the thing in place)
    - also could use turn keys to add force and friction to hold in place
- the extrusion element for positioning at the intersection
    - could be removable (not necessarily rotating about the pivot point)
- sample holders
    - could be 3D printed
    - open source stereotax
        - paper with solidworks files that includes apparatus to hold the head still etc
        - would eliminate the vibrations caused by the breathing of the specimens
        - 3D PRINTED RODENT STEREOTAXIC DEVICE
            - reference whatever designs we utilized or based off of
    - paramount on us to design something that accomodates a variety of sample holder

Conclusions/action items: The SolidWorks drawing of the design will be updated, especially to include the component for positioning at the intersection of the axes. The latest drawing will be used to 3D print a scaled version of the design as a proof of concept. Other members of the group will be researching potential materials and methods for fixing translational components. Once materials have been researched, the team will convene to discuss the most effective means and the materials necessary for fabricating a full-sized version of the design. Materials will then be ordered such that fabrication will commence once materials arrive. The team will also begin looking into implementing different sample holders, such as the stereotax as documented.

11/01/2019 Meeting 6

▪ Kurt Vanderheyden ▪ Nov 04, 2019 @03:06 PM CST

Title: Advisor Meeting 6

Date: 11/01/2019

Content by: Kurt Vanderheyden

Present: Whole Team

Goals: Discuss our progress so far with creating the 3D printed prototype and see what Aaron thinks. Ask about material suggestions and what else he recommends for the show and tell session. Receive feedback on the initial report.

Content:

- the current prototype idea meets the rotational and translational capabilities in theory, need to assemble to see how well it truly does
- Aaron thinks we are at a really good starting point and that we need to get full scale with real materials.
- Machining and printing of pieces
    - the base pizza element should be machined out of cheap metal like aluminum or acetyl/delrin
        - cheap plastics that are machinable, slippery, and ware resistant
        - material isn't too important because gravity will hold stage in place
        - an attachment like bearings or a latching mechanism could be added to keep in place and allow for easy rotation
        - future work could be possibly adding a motor underneath to make movement automatic
        - could also use magnets to lock in place
    - for the cylinders that the allow for other rotation, pvc parts can be used but holding in place would be difficult
        - metal with magnets could allow for the rotation to stick in place (Kevin's ideas)
        - mcmaster carr and home depot probably have pipes big enough for the diameters necessary
        - might be difficult matching the ID and OD of the two different parts
        - two pipes could be CNC together
        - we could mill the outer pipe but inner tube would be more difficult and printing full size scale would be iffy
    - rods for the different translational elements can just be lead screws that are paired with square nuts to lock in
        - the z small rods might need to be larger in diameter do to holding the weight of the animal and a stage
        - the rods/ lead screws can be found on mcmaster carr
    - the sight piece can be 3D printed
        - the small rods that go through the sight piece could be provided by Dr. Suminski, be could give us electrode stylets from his lab
        - need to ask Ben about the alignment tool and if he thinks it will get in the way
- Overall, he doesn't think that fabrication of the actual device would be too difficult and that we would be able to do it
- we should try our best to assemble to prototype fully and see how it works and show it to the client as soon as possible to receive feedback
    - proof of concept testing with an actual mouse would be beneficial to see what size is actual necessary to fit the different rodents and if the device works
    - client might be able to send our design to a company to fabricate the device for us if they like what they see
- For show and tell, Dr. Suminski thinks we have everything necessary and we don't need to worry
- we should wait on ordering materials until after we meet with the client and get everything to work first.

Conclusions/action items: In conclusion, we received beneficial feedback on our first printing of the prototype and possible materials we can use to make the actual product. The next things necessary for us to do are get the prototype fully assembled to see how functional it is, then show this to the client to receive feedback. If all goes well, materials should be ordered to actual machine and make the final product for our client and for testing. Show and tell is a week from today and for that we should prepare our elevator speech and make sure our prototype is assembled to show the other groups our progress thus far.

11/15/2019 Meeting 7

▪ RILEY PIEPER ▪ Nov 15, 2019 @02:50 PM CST

Title: Client Meeting 7

Date: 11/15/2019

Content by: Riley Pieper

Present: Full Team

Goals: Discuss the work done in the past week with our advisor. Specifically relay the input from the client relating to the fabrication methods and the materials to be used. See if our advisor has any additional input about our project.

Content:

- could make components of the design that are currently one piece of multiple pieces
- CNC milling?
    - talk to the shop about what we need to provide and what we can get out of that
    - is it even an option provided the Solidworks that we have?
- testing
    - set up a test rig with an iPhone camera
    - compute errors from the original/best value of being at the center
    - **keep the time of how long it takes to get to that center of rotational axes**
    - come up with a procedure to determine whether the eye is aligned properly IN PRACTICE
- can look at different vendors from ThorLabs that might be cheaper - precision-machined rods
- poster presentations -- Dec 6
- final deliverables -- Dec 11
- lots of fabrication at this point
- **come to the lab to get the alignment styluses**
    - **send him an email and he will likely be there**
- can think of other components such as the stage and the external translation as components that can be added to our design
    - make sure that our stage is compatible with things on the market that can be used for that purpose

Conclusions/action items: At this point, the immediate objective is to get materials and begin fabrication as soon as is possible. We will meet immediately following this advising meeting to make a list of materials to be sent to the client for validation and look at potential scrap parts that can be used. Moving forward, the team will designate members to do the fabrication while other members of the team will begin work on final deliverables.

11/22/2019 Meeting 8

▪ RILEY PIEPER ▪ Nov 22, 2019 @07:21 PM CST

Title: Client Meeting 8

Date: 11/22/2019

Content by: Riley Pieper

Present: Full Team

Goals: Get input from advisor regarding some of the issues we have been having with finding materials and fabrication; show him the scrap materials that we have acquired and the fabrication we have done on them.

Content:

- Use thermoplastic to mold one of the cylinders
    - mold to the other cylinder that we have
    - not cost prohibited?
    - get in different thicknesses?
- drill and countersink when screwing so surfaces remain flush
- get a bearing that will help the smoothness of rotation?
    - metal shaft - use a thinner
    - **McMaster Carr**
- lookup specifications for what a press fit for a shaft should be
    - specific drill and tap should be
    - same for interference shaft
- not too concerned about the pricing of the materials
    - low on the list of things to be concerned about
    - send an email every day reminding
- be a polite nuisance about ordering materials
    - compile a list of everything we need to order
    - tell them where it is
        - part number
        - description
        - quantity
        - link of the webpage where to find it
    - **put a cart together and send them a link to the cart**
- "based on budget constraints, we used this"
- "to do this the right way, this is how we would do it - it would cost this"
- **COUPLINGS**

Conclusions/action items: At this point, we will procure a full list of the materials necessary and send that to our client so that he can order the materials for us in a timely manner. The team will do this by looking into pipes and couplings that could act as concentric cylinders. Once materials are ordered, fabrication processes will be carried out and completed. This is the final advisor meeting of the semester, so any further inquiries will be carried out over email.

12/11/2019 Design Specifications (Retroactive)

• NOLAN THOLE • Dec 11, 2019 @01:23 AM CST

Title: Design Specifications

Date: 12/11/19

Content by: Nolan Thole

Present: Full team

Goals: Provide the necessary design specifications as decided upon by the team.

Content:

The client provided us with some of the specifications that he had for this design. These included:

- Design needs 5 degrees of freedom, 3 translational and 2 rotational
- Pupil of animal must align to the center of rotational axes
- Design must include an open concept to allow for imaging and a nose cone to administer anesthesia to rodent
- Surfaces should be smooth to allow facile sterilization
- Translational precision should be within 100 microns

As a team we has some design requirements which included physical and operational characteristics, production characteristics, and miscellaneous things

Physical and Operational Characteristics

- The design should be able to allow for 5 degrees of freedom while still keeping the eye aligned at the center of rotational axes
- Design needs to be open to allow for the imaging device and the anesthesia administered to the rodent
- The rodent should be safe in the sample holder and not move around or fall out or be able to be harmed in any way
- The device should support a specimen up to 1 pound and should last for up to 5 years under normal operating conditions
- The translational and rotational components of the design should be easy for the researcher using the device
- Design should not be overly large compared to a rodent
- Device should weigh less than 10kg to allow for easy transportation
- Material cost cannot exceed $350 budget

Production Characteristics

- 1 device is required for this project and multiple sample holders are required for different sized specimens
- Budget given by client was a loose $350

Miscellaneous

- Bioptigen has a competing device but is not on the market anymore and did not allow the eye to be placed at the center of axes of rotation
- Sample holder should be symmetrical

Conclusions/action items:

In conclusion, our final prototype met most of the design specifications we proposed. The device kept the eye of the rodent in the center of axes of rotation reasonably well. This means that the client can align the eye once at the beginning of research and not have to adjust it again while rotating the device. The only piece we didn't accomplish was making different sample size holders for various sizes of specimen. This was because the design team focused on the part of the design to perfectly keep the eye at the center of rotational axes. The team felt this was the most crucial part of the design and wanted to make sure we got this right. We didn't end up making the sample holders this semester, but in the future if we were to continue this project we would make numerous different sized holders to incorporate into the design.

12/11/2019 Preliminary Design Evaluation (Retroactive)

▪ Kurt Vanderheyden ▪ Dec 11, 2019 @01:16 AM CST

Title: Preliminary Design Evaluation (Retroactive)

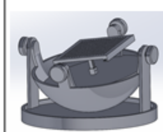
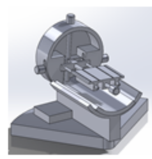
Date: December 12, 2019

Content by: Kurt V

Present: Whole Team

Goals: To evaluate our preliminary design

Content:

Criteria	Design 1: Bowls 	Design 2: Pizza 	Design 3: Field Goal 
Ease of Adjustment (20)	3	5	3
Rotational Freedom (18)	5	4	3
Translational Freedom (15)	3	4	2
Ease of Fabrication (12)	3	2	5
Sterilizability (12)	4	3	3
Strength (8)	2	4	2
Safety (5)	4	5	4
Simplicity (5)	3	2	5
Cost (5)	3	1	5
Total (100)	69	72.8	65.2

- Ease of Adjustment= key feature for easily positioning and adjusting the eye of the specimen being imaged
- Rotational freedom= important to image the retina easily and holistically
- Translational freedom= important to be able to translate within the rotational elements so the pupil of the eye can be accurately positioned at the intersection of the rotational axes
- Sterilizability and ease of fabrication= equally as important to develop a prototype to conduct testing while meeting client's wishes for smooth surfaces to allow for cleaning between imaging trials
- strength, safety, simplicity, cost= all considered for consideration but low rankings due to the client not emphasizing the importance of these different elements

Conclusions/action items:

From analyzing the three different preliminary designs, the pizza design was the design that ranked the highest, and also met the most amount of criteria created. This caused us to go with the pizza design in our fabrication and final design plans. Along the way, the design got manipulated multiple times due to materials or making the fabrication process simpler based on the time constraints of one semester. This led us to the final design of the diamond RRaTS for our client.

10/8/2019 Chosen Preliminary Design

▪ RILEY PIEPER ▪ Oct 08, 2019 @06:36 PM CDT

Title: Chosen Preliminary Design

Date: 10/8/2019

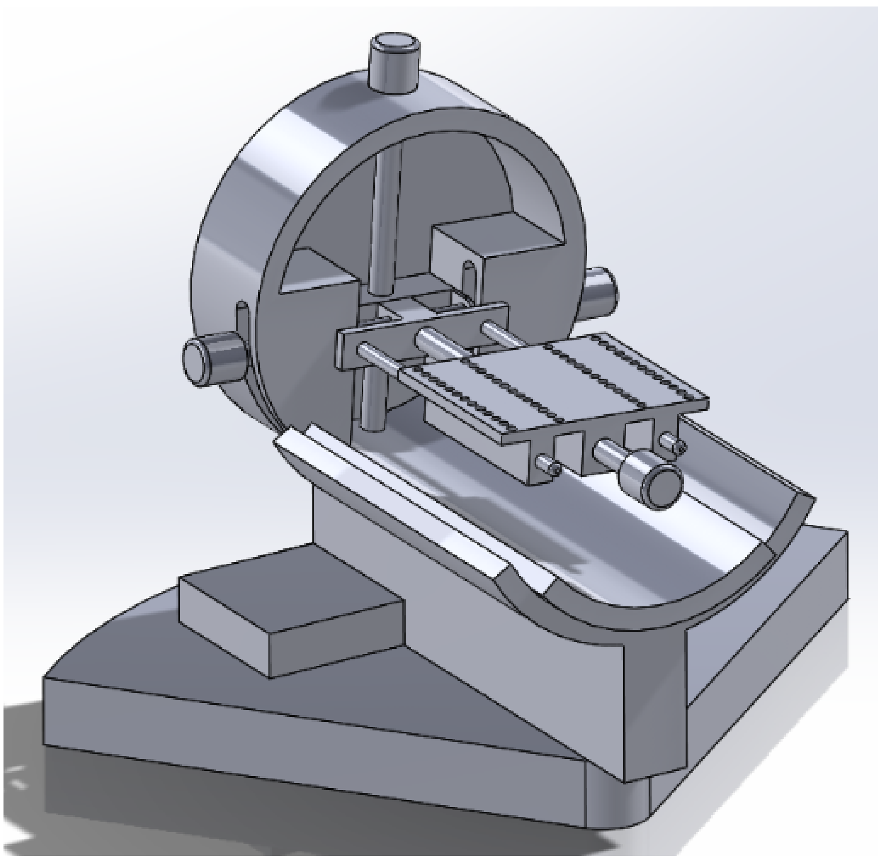
Content by: Riley Pieper

Present: None

Goals: Communicate the design that the team has chosen to move forward with at this time as well as the key features evaluated to come to this decision.

Content:

After members of the team presented the designs that they brainstormed individually, we decided upon the Pizza design, based on evaluation via the design matrix. The Pizza design is pictured below.



The Pizza design has been determined to be the most optimal due to the fact that is presents the 5 most important degrees of freedom (three internal translation and the two necessary rotation: pitch and yaw) without adding unnecessary complexity (such as the third rotational degree of freedom). Based on the request of the client to make the design composed of largely smooth surfaces to facilitate sterilizability, the rotational components are friction based (alike the Bioptigen RAS design). On the other hand, the importance of aligning the center of the specimen pupil at the intersection of the rotational axes accurately is accomplished via threaded rods along which the sample holder stage translates (within the rotational axes), controlled by turning dials. The stage itself is covered with threaded holes providing flexibility for eventual attachment of a variety of sample holders.

Conclusions/action items: This design has already been presented during the preliminary presentation as the design that we will move forward with. It will also be written about accordingly in the preliminary report. Moving forward, the team will begin determining the materials required to fabricate a prototype of this design as well as specific plans for how to do so. Along the way, this design may be changed or updated to fully meet the requirements of the client and solve the problem that this team is faced with. Two specific areas that will be immediately considered include a means of locating the intersection of the rotational axes where the pupil must be positioned, potentially via lasers or sights, and an integration of this device with a holding cart and adjustable height to provide three crude external translation degrees of freedom in addition to the three internal degrees of freedom.

10/17/2019 Post-Prelim Action Plan

▪ RILEY PIEPER ▪ Oct 17, 2019 @04:13 PM CDT

Title: Post-Preliminary Deliverables Action Plan

Date: 10/17/2019

Content by: Riley Pieper

Present: Kurt Vanderheyden

Goals: Document a preliminary plan for the action necessary moving forward, given the feedback received from our client and advisor.

Content:

Bowls vs Pizza Design

- to some extent, the client felt that the pizza design was overcomplicated
  - largely due to the dial components relating to the internal translation
- liked the idea of the bowls design
  - could remove fixed pivots and allow free sliding across concentric bowls?
- downside of bowls design: size
  - center of rotation in the *middle* of bowls - eye in front of rat/mouse
  - must be twice as large as mouse for eye to be centered on axes
- pizza design:
  - center of rotation (pivot) at the front of the cylinder
    - allows the eye of the rodent to be at the rotation axes and the body of the rodent to lay across cylinder length

We will move forward with the pizza design, largely based on this argument.

Locating Intersection of Rotational Axes

- physical retracting rods that intersect at the point in space
- slide through eyelets on extrusions in front of the cylinder to locate the point and allow the position of pupil
- extrusions can pivot around the same pivot as the cylinder (independent of cylinder)
  - rods can be removed - are separate from this design
  - allow the extrusions to be out of the way of the camera FOV

We will implement this extrusion component to the pizza design. The components will be added to the SolidWorks drawing.

Proof of Concept Fabrication

- 3D print to about 1/3 - 1/2 scale all parts of pizza design to see how they fit up and work
- can use the resin printer
  - as opposed to the 'writing' printer
  - adds resolution
  - smoother surface finishes
  - elements may be able to slide past one another
- implement the extrusion for positioning at the intersection of the rotational axes

Simplification of Internal Translation

- preliminary action - eliminate threaded elements in the POC fabrication - see how well elements slide past one another
- research friction materials that can be adjusted but hold in place
- main issue: z axis (holding against gravity and the weight of the specimen)
- if the friction approach is not feasible, move back to threaded components

Conclusions/action items: According to this discussion, we are moving forward, at this point, with a design similar to the Pizza design - using many of the components of this design that were presented in the preliminary presentation as a starting point. In order to solve the problem of locating the point of the intersection of the rotational axes, extrusions with retractable rods (with pointed ends) will be added to the design. This component of the design will be implemented into SolidWorks drawings to create our most up-to-date version of the design. The team will present our advisor with a crude physical example of this design to gauge his understanding and thoughts on it. In the near future, the team will commence initial fabrication of proof of concept via 3D printing at the MakerSpace. The parts will be fabricated from the most up-to-date version of the Pizza design drawing using a resin based printer. Other members of the team not involved in the printing will begin researching materials that could be used to fabricate the full design, especially paying attention to the friction properties of the materials as they could be used to facilitate translational and rotational adjustment of the stage.

11/9/2019 Show And Tell Notes

▪ KEVIN TAN ▪ Nov 09, 2019 @01:12 PM CST

Title: Show And Tell Notes

Date: 11/8/2019

Content by: Kevin Tan

Present: Riley Pieper, Kyle Schmidt Nolan Thole, Kurt Vanderheyden, Kevin Tan

Goals: Record suggestions and ideas from show and tell

Content:
-Size of pipe how big does it have to be? Our answer: just enough for friction.
-Add notches or markings to make adjustments to certain angles easier/reproducible
-Built in warming blanket would be very useful
-How will we test it? Our answer: work with the client. Outside of that however, what tests can we do?
-Design the specimen holder so that the rat doesn't shift during rotation
-Align the imaging device when the alignment rods are extended and meeting at the center of the rotational axes.
-Rubber on the bottom of the rotation device for extra friction
-Simplify the shapes on the alignment rod holder.
-Consider the maximum height of specimen that can be imaged in our current design. We may need to increase the size of the pipe.
-Use screws to apply more friction

Conclusions/action items: Consider the above feedback and discussion gained from show and tell. Continue fabrication planning with those considerations in mind.

12/11/2019 Diamond RRaTS Design (Final)

▪ RILEY PIEPER ▪ Dec 11, 2019 @12:30 AM CST

Title: Final Design: Diamond RRaTS

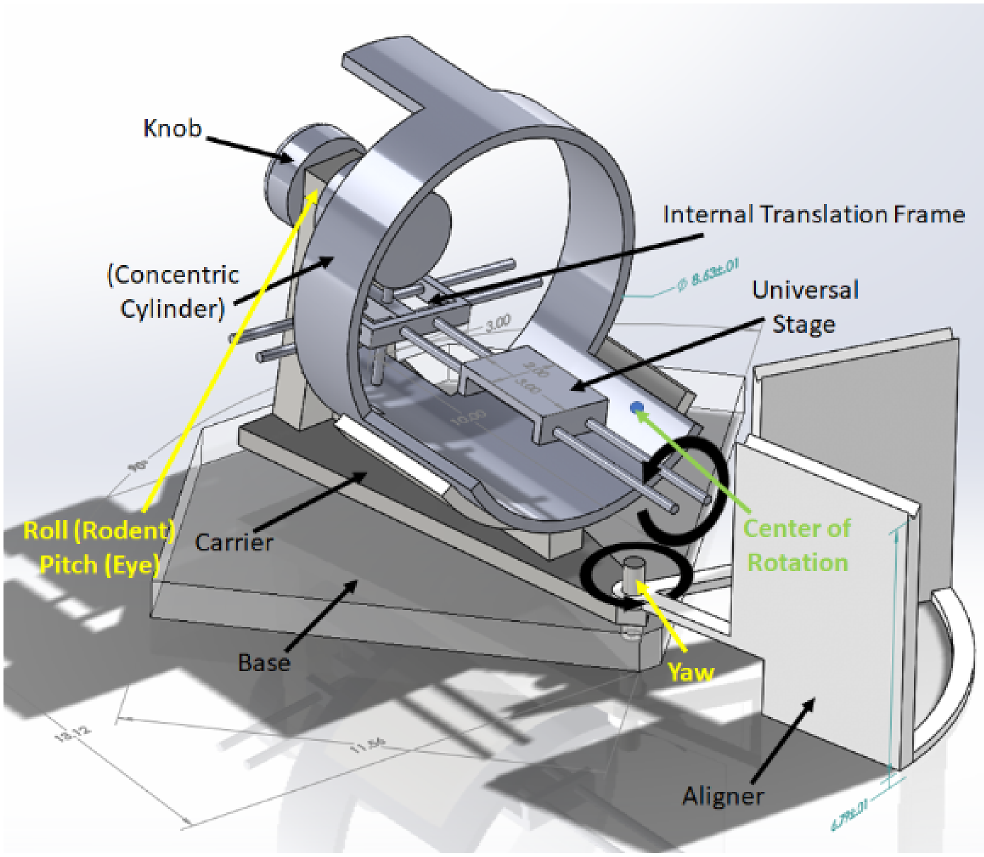
Date: 12/11/2019

Content by: Riley Pieper

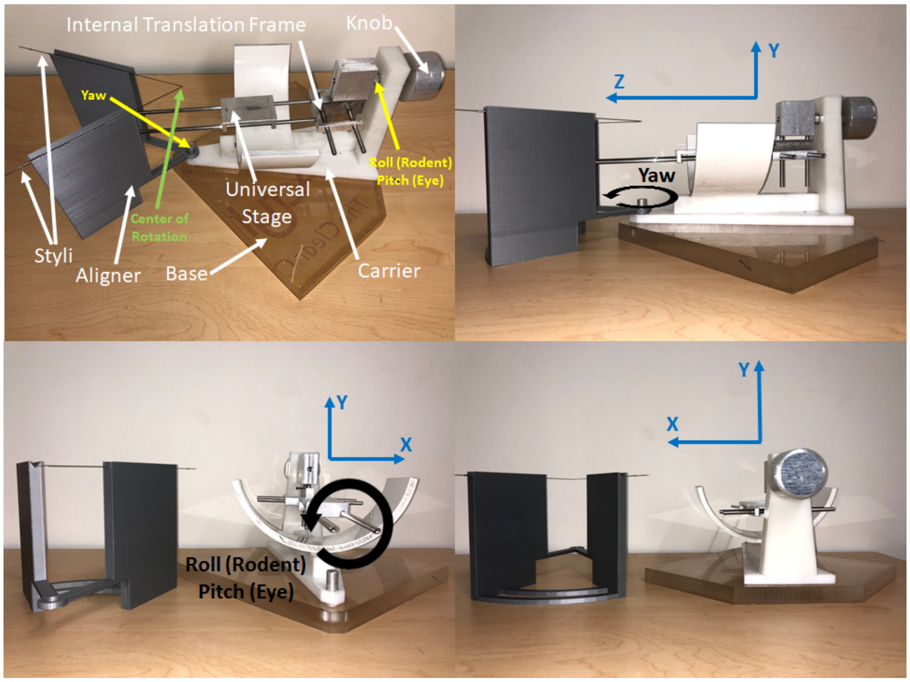
Present: Full Team

Goals: Present the final design as drawn in SolidWorks and fabricated for presentation and testing procedures

Content:



Above is the labeled and dimensioned design as drawn in Solidworks. This design is the ultimate result of improvements made to the proposed final design, the Pizza Design, following preliminary design analysis. Notable improvements include a removable aligning device that houses extending probes meeting at the intersection of the two axes of rotation such that the eye of the imaged specimen can be aligned along the internal translation to the center of rotation as well as minimization of the concentric cylinder to promote access to the specimen and the adjustable components. Additional changes from the Pizza Design were made to accommodate the stock materials available for fabrication.



This Diamond RRaTS design, as fabricated, is presented in the image above. One notable difference between the physical prototype and the design drawing is the lack of the concentric cylinder component. The inclusion of this part is intended to add stability of the rodent roll rotation via frictional contact with the partial-cylinder of the aligner. However, due to the fact that the larger of the cylinders was fabricated from a PVC coupling, implementation of the internal concentric cylinder put strain on the internal translation rods, so it was not included. Friction between the knob and the back of the carrier provides sufficient friction to hold the universal stage in place following rotation.

Conclusions/action items: This design will be implemented into the final report for submission to our advisor and client as completion of this design project. As this concludes the semester, the prototype that we completed will be given to the client for potential implementation into his imaging system for use in holding specimens and facilitating the imaging process. Even so, all of the drawings in solidworks and relevant materials will be made available to potential future groups to continue this project and improve upon the work that we have done and implement some of the future work that we suggested in another document.

12/11/2019 Future Work

▪ RILEY PIEPER ▪ Dec 11, 2019 @12:42 AM CST

Title: Potential Future Work Ideas

Date: 12/11/2019

Content by: Riley Pieper

Present: Full Team

Goals: Present some potential ideas as future work improvements that could be made to our design with future work on this project.

Content:

- internal concentric cylinder implementation
    - contribute to stability of internal translation
        - decrease downward deflection
        - decrease deviation of eye during rotation
    - hold stage in place better after rotation adjustment
    - cylindrical components must be precision machined to fit together
        - no taper of the coupling that we used
- Create implementable sample holders
    - flexibility for various specimens
        - rats
        - mice
        - single eyes
    - include elements like warming blanked, bite bar, fit of anesthesia cone
- implement with full imaging system on a CART
    - cart provides additional 3 degrees of translation
    - allow to bring stage into camera FOV
    - allow design to be validated with the full imaging device
- add motor to automatically adjust the stage
- use materials that are safe in an autoclave
    - make easily sterilizable

Conclusions/action items: These future work ideas can be implemented by a future design team that works on this project. These are clear next-steps to both make this design to be implemented into the practice of the client and to improve the efficiency of this design in process. If another team were to pick this project up, this notebook as well as the materials that we have procured throughout the semester will be used to inform this team such that they do not start from square 1 in their design process.

Ordered Parts

▪ KYLE SCHMIDT ▪ Dec 09, 2019 @09:27 PM CST

Title: Ordered Parts

Date: 11/22/19

Content by: Kyle Schmidt

Present: All

Goals: Create a list of parts to order to send to our client

Content: See Below

Conclusions/action items:

With our neatly organized spreadsheet, we can send our list to our client to order for us, and then begin fabrication

▪ KYLE SCHMIDT ▪ Dec 09, 2019 @09:26 PM CST

Embedded private docs from Google Drive cannot be displayed in PDF

Cost of Materials

• NOLAN THOLE • Dec 10, 2019 @01:25 PM CST

Title: Cost of Material

Date: 12/10/19

Content by: Nolan

Present: None

Goals: Finalize list of expenses

Content:

Expenses

Component 1							
Half-scale model	3D Printing Material for Scale Model	Makerspace	NA	10/28	1	$40	$40
Component 2							
Cylinder part (inner)	8” PVC Pipe in 5 foot section	McMaster Carr	48925K26	11/22	1	$82.59	$82.59
Component 3							
Cylinder part (outer)	8” coupling individually	McMaster Carr	4880K132	11/22	1	$25.30	$25.30
Component 4							
Internal translation	3” rods come individually	Thorlabs	ER3-P4	11/22	2	$6.80	$13.60
Component 5							
Internal translation	4 pack of 3” rods	Thorlabs	ER3-P4	11/22	1	$25.83	$25.83
Component 6							
Internal Translation	10’ rods comes individually	Thorlabs	ER10	11/22	2	$13.08	$26.16
Component 7							
Set Screw	4-40 ⅜”	Fastenal Company	25028	11/22	15	$.08	$1.20
Component 8							
Set Screw	4-40 ½” comes individually	Fastenal Company	25030	11/22	10	$.19	$1.90
Component 9							
Alignment tool	3D Printing alignment tool	Makerspace	NA	12/04	1	$20.94	$20.94
TOTAL:							**$237.52**

Conclusions/action items:

Our total project cost $237.52 to fabricate, not including the scrap materials we found to use. This is under our budget of $350 given to us, however, it would have cost more if we could not find scrap materials and had to order those materials as well.

12/11/2019 Base Fabrication

▪ RILEY PIEPER ▪ Dec 11, 2019 @01:35 AM CST

Title: Base Fabrication

Date: 12/11/2019

Content by: Riley Pieper

Present: Kevin Tan

Goals: Fabricate (communicate the processes of fabrication) the base of the final Diamond RRaTS design.

Content:

- stock acryllic material 12 in by 12 in and 1 in thick obtained (scrap bin)
- band saw used to cut the base into correct shape
    - small cut made at 45 degrees 1/2 in from one corner
    - other 45 degree cut made off opposite corner 5 in from the corner
    - final, cut base should look like a diamond (hence the name)
- drop saw used to drill a 1/2 in diameter hole to depth of 3/4 in

Conclusions/action items: These fabrication processes will be implemented by other people for reproduction of this design or by future teams interested in recreating this design for improvement. This base component serves to support the remainder of the design, as the carrier component pivots/glides across it as one degree of rotation.

12/11/2019 Carrier Fabrication

• RILEY PIEPER • Dec 11, 2019 @01:44 AM CST

Title: Carrier Fabrication

Date: 12/11/2019

Content by: Riley Pieper

Present: Kevin Tan

Goals: Fabricate (communicate the processes of fabrication) the carrier of the final Diamond RRaTS design.

Content:

- 1 in thick HDPE slab obtained from the scrap bin of the blue room
- 1/2 in thick HDPE also obtained
- 8 in coupling obtained
- cuts made on the band saw according to the dimensions of the solidworks image (drawing attached)
- bottom portion cut from the 1/2 in thick stock
- riser and back portion cut from the 1 in thick stock
- bottom portion first fixed to the back portion via construction screws
    - pilot holes must first be drilled to eliminate any displacement of material during drilling
- riser component fixed to these other two component also via construction screws
- 8 in coupling cut to create semi-circle (at 3 in in length)
- semi-circle centered on the riser component and epoxied in place
    - ensure that the part is not touched for 10 min
- hole at the front of the carrier drilled with a 1/2 diameter drill bit
- 1/2 in aluminum rod cut to 2.5 in length and used to fit through carrier into base to connect two components and allow them to fit
- back portion of the part drilled through with a 1/2 in diameter according to the dimensions of the solidworks drawing
    - this dimension should be verified and drilled *last* as it must be precisely in the center of rotation and aligned with the hold in the front and the base

Conclusions/action items: These fabrication processes will be implemented by other people for reproduction of this design or by future teams interested in recreating this design for improvement. The carrier component will hold the rotating portion of the design in place and ensure that it rotates (rolls) correctly while holding it in place when adjustment has occurred.

• RILEY PIEPER • Dec 11, 2019 @01:43 AM CST

Carrier.SLDPRT(136.5 KB) - download

12/11/2019 Concentric Cylinder Fabrication

▪ RILEY PIEPER ▪ Dec 11, 2019 @01:49 AM CST

Title: Concentric Cylinder Fabrication

Date: 12/11/2019

Content by: Riley Pieper

Present: Kevin Tan

Goals: Fabricate (communicate the processes of fabrication) the concentric cylinder of the final Diamond RRaTS design.

Content:

- obtain an 8 in PVC pipe and cut to length of 8 in using a drop saw
- use a band saw to cut 2 in wide protrusion across from one another on the cylinder that go 3 in deep into the cylinder
- drill holes 1.5 in apart that can be tapped with a 4-40 tapped hole that can be screwed into
- use a hack saw to cut the front cylinder down to 110 degrees of the circumference to a depth of 3 in on the side opposite of the protrusions
- use a file to smooth all rough edges

Conclusions/action items: These fabrication processes will be implemented by other people for reproduction of this design or by future teams interested in recreating this design for improvement. The concentric cylinder serves to stabilize the stage on the internal translation, keep it straight and provide friction to hold the stage at high rotation angles. This component was fabricated but not included in the final design prototype, as tapering of the coupling of the carrier caused this concentric cylinder to put strain on the rods of the internal translation, making the design less effective than it is without this cylinder. In the future, these cylinders should be more precision machined so that no strain is put on the rods and it fits to add friction and correct alignment to the stage.

12/11/2019 Aligner Fabrication

▪ RILEY PIEPER ▪ Dec 11, 2019 @01:54 AM CST

Title: Aligner Fabrication

Date: 12/11/2019

Content by: Riley Pieper

Present: Kevin Tan

Goals: Fabricate (communicate the processes of fabrication) the aligner of the final Diamond RRaTS design.

Content:

The aligner was 3D printed to the size percribed by the solidworks drawing of this component. The STL file to be uploaded to the printer is attached to this entry

- PLA used on an Ultimaker in the MakerSpace of UW Madison
- print took approximately 17 hours
- supports must be removed following printing completion

following printing, telescoping neurosurgical styli are superglued into the ridges of the 3D printed part.

Conclusions/action items: This component of the design can be position on the rod used to connect the base and the carrier and also removed when done with use. This component pin points the spot in space at which the axes of rotation intersect. Therefore, it is crucial in positioning the eye, in conjunction with the internal translation components, at the center of rotation to fix it in space during imaging procedures. This component can easily be 3D printed again for reproduction.

▪ RILEY PIEPER ▪ Dec 11, 2019 @01:54 AM CST

Aligner.STL(33.4 KB) - download

12/11/2019 Internal Translation Fabrication

▪ RILEY PIEPER ▪ Dec 11, 2019 @02:10 AM CST

Title: Internal Translation Fabrication

Date: 12/11/2019

Content by: Riley Pieper

Present: Kevin Tan

Goals: Fabricate (communicate the processes of fabrication) the internal translation components of the final Diamond RRaTS design.

Content:

- 2 10 in 6 mm diameter rods obtained (Z translation)
- 2 3 in 6 mm diameter rods (Y translation)
- 4 3 in 6 mm diameter rods (X translation)
- 5/2 in diameter cylindrical stock cut to 2 in length and chamfered to act as the knob.
    - 1/2 threading drilled into the center of the knob for attachment
- threaded rod 1/2 diameter cut to 2.5 in
    - connects the knob and the translating anchor block through the back of the aligner
- anchor block fabricated from a 1 in thick aluminum stock cut to 2 in by 2 in
    - 1/2 threading drilled into the center of the knob for attachment
        - used a drill press and a tap
    - 4-40 tapped holes made on a 1 in thick side perpendicular to the 1/2 in threaded hole
        - holes drilled 1.5 in apart
- two 3 in rods attached to 4-40 holes of the anchor block via set screws (come with the rods)
- C - brace fabricated from a hollow stock to 2.5 in width and 2 in depth
    - thickness = 0.25 in
    - 6 mm holes through short sides of the brace milled with a reamer (such that rods could slide through them)
    - in front, two more 4-40 tapped holes drilled
        - two 10 in long rods screwed into these holes, attached with set screws
- center block fabricated from a 1/2 in thickness stock to 3/4 in by 2 in
- holes for rods to pass through reamed (6mm) 1.5 in apart through the top (1/2 thick side)
- 4-40 tapped holes drilled on sides 1.5 in apart (to miss the 6 mm holes)
    - two 3 in rods screwed into each of the holes (4 total)
- internal translation components assebled according to the solidworks drawing
- Universal Stage
    - fabricated from same hollow aluminum stock as C brace
    - cut to 2 in thick with .25 in sides
    - 6 mm holes reamed through sides 1.5 in apart so 10 in rods can pass through (stage glide along)
- all aforementioned components assembed according to the solidworks assembly attached

Conclusions/action items: These fabrication processes will be implemented by other people for reproduction of this design or by future teams interested in recreating this design for improvement. These components are central to this design, as they provide the ability to align the specimen such that the imaged eye is at the center of rotation. They must be precision machined on a mill such that all of the holes provide the necessary friction as the rods pass through, but allow the rods to pass through relatively easily to lend to ease of adjustment. In the future, the universal stage might need to be updated to be able to attach various sample holders that could be implemented.

▪ RILEY PIEPER ▪ Dec 11, 2019 @02:10 AM CST

DiamondRRaTS.SLDASM(176.2 KB) - download

12/11/2019 Deflection from Intersection

▪ RILEY PIEPER ▪ Dec 11, 2019 @12:50 AM CST

Title: Eye Deflection from Intersection of Rotational Axes

Date: 12/11/2019

Content by: Riley Pieper

Present: Full Team

Goals: Outline the procedures taken to quantify the change in position of the eye following alignment of the eye as staged on the design while rotation occurs.

Content:

The device was tested to see if the eye was kept at the intersection of the axes for various amounts of rotation in both the yaw and pitch directions.

- stuffed animal badger was placed inside a makeshift sample holder made out of a PVC pipe and taped on the universal stage
- subject's left eye was positioned to the center of rotation using the internal translation and the alignment styli
- began to rotate the stage in the yaw direction at 15 degree increments with help from a protractor until the carrier was rotated 45 degrees from the starting point
- at each turn, a fixed camera captured an image of the subject and stage
- image processing software named *ImageJ* was then used to calculate the deviation of the subject's eye from the center of rotatio
- similar process was then carried out in the pitch direction where the stage was rotated in 7.5 degree increments until the universal stage was rotated 30 degrees from the origin
- captured images were uploaded into *ImageJ* and analyzed to calculate the deviation from the center of rotation.

Conclusions/action items: Following conduction of this testing procedure, the measurement data was collected to be analyzed and presented. The presented data will be presented during the final presentation and final report. This data will be analyzed to determine how effective the design is in keeping the eye in the same position during rotation. These results will inform the success of this design and suggest whether improvements must be made in the future. Future groups may use these same testing procedures to conduct similar testing to determine if their updated design is more effective. See entry in experimentation for results of this testing.

12/11/2019 Beam Deflection

▪ RILEY PIEPER ▪ Dec 11, 2019 @12:56 AM CST

Title: Beam Deflection Testing Procedures

Date: 12/11/2019

Content by: Riley Pieper

Present: Full Team

Goals: Quantify the deflection of the beams holding the universal stage under measured loads that are representative of rodents that may sit on it during imaging to evaluate the strength of these elements of the holder.

Content:

The device was tested for the amount of beam deflection that would occur under various loads.

- rods deflecting could impact the ability of the eye to remain in the center of rotational axes
    - Too much deflection could cause the eye to become unaligned with the center of rotation during rotation and from small vibrations in the environmen.
- varying masses were placed on the two z-axis translational rods
- deflection was measured using a digital caliper
- The center of mass of the masses were placed at the center of the rods
    - 5 inch (12.7 cm) mark
- deflection was measured at the 10 inch (25.4 cm) mark
- simulate various weights of rodents being placed in the middle of the rods and the location of its eye deflecting
- The rods under no load was used as a zero for the deflection. Increasing masses were added after each deflection was measured.

Conclusions/action items: Following conduction of this testing procedure, the measurement data was collected to be analyzed and presented. The presented data will be presented during the final presentation and final report. This data will be analyzed to determine how effective the design holds the specimen level while supported from the center of the long protruding rods. These results will inform the success of this design and suggest whether improvements must be made in the future. Future groups may use these same testing procedures to conduct similar testing to determine if their updated design is more effective. See entry in experimentation for results of this testing.

12/11/2019 Alignment Time

▪ RILEY PIEPER ▪ Dec 11, 2019 @01:00 AM CST

Title: Alignment Time Testing Procedures

Date: 12/11/2019

Content by: Riley Pieper

Present: Full Team

Goals: Test the time it takes for inexperiences subjects to align the eye of the specimen at the center of rotation.

Content:

- test was also conducted to test the time it took for one person to align the pupil of a specimen in the center of rotation with the aligner.
- 7 trials were conducted with 7 different participants using the device to align the pupil in the center of axes of rotation
- stuffed animal was used in place of a live specimen
- The stuffed animal was then fixed to the universal stage using the makeshift sample holder (small PVC pipe)
- Before each trial, the eye was shifted from the center of rotation in a randomized manner
- To simulate actual usage of the device, the center of rotation was defined as the point where the aligning styli met
- A time measurement was taken for each trial with stop watch starting when the person touched the device to start aligning and ending when the person took his/her hands off the device after successfully aligning the eye at the center of rotation
- An average time taken to align the eye was calculated based on the 7 trials.

Conclusions/action items: Following conduction of this testing procedure, the measurement data was collected to be analyzed and presented. The presented data will be presented during the final presentation and final report. This data will be analyzed to determine how easily the sample can be aligned and how much additional set up time is required prior to beginning the imaging process. These results will inform the success of this design and suggest whether improvements must be made in the future. Future groups may use these same testing procedures to conduct similar testing to determine if their updated design is more effective. See entry in experimentation for results of this testing.

12/11/2019 Deviation from Intersection Results

▪ RILEY PIEPER ▪ Dec 11, 2019 @01:18 AM CST

Title: Eye Deflection from Intersection of Rotational Axes Results

Date: 12/11/2019

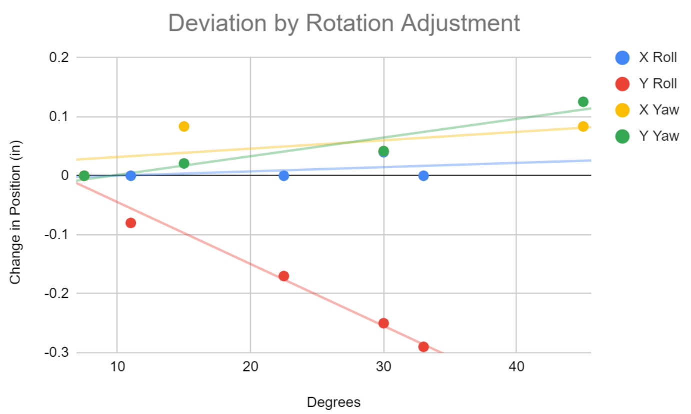
Content by: Riley Pieper

Present: Full Team

Goals: Present the results of the testing conducted to determine how far the eye moves after aligned when the stage is rotated. Analyze these results to determine the success of this design and improvements that must be made.

Content:

Find testing procedures in the team Protocols folder.



Devaion by Rotation Adjustment

	Deviation (inches)			
Rotation (˚)	X Roll	Y Roll	X Yaw	Y Yaw
0.0	0.000	0.000	0.000	0.000
7.5	0.000	-0.080		
11.0			0.084	0.021
15.0	0.000	-0.170		
22.5	0.040	-0.250	0.042	0.042
30.0	0.000	-0.290		
33.0			0.084	0.125
45.0			0.042	-0.042

The raw data present in the table is also represented in the plot. Data is separated by axis of deviation and the rotation direction being adjusted.

Conclusions/action items: It is clear that there is relatively insignificant movement of the eye with rotations up to 30 degrees with the exception of in the Y direction during roll. It is suspected that deflection of the support rods may have contributed to this, so increasing the stability/strength of these rods may help fix this deviation. However, this relatively significant deviation likely also calls for more precision machining of the design in order to minimize movement of the eye during the rotation adjustment required for imaging. This is important to the client because when the eye moves during rotation, it moves out of the field of view of the camera and must be repositioned. One potential source of error in these results is the fact that the 'sample stage' used was a pvc pipe holding a stuffed animal (specimen) that was duck taped to the universal stage. This was not completely secured to the stage, so it may have moved independently of the universal stage. Thus, when actual sample stages are created, they must be well fixed to the universal stage so that they do not move and, in turn, move the eye being imaged.

12/11/2019 Beam Deflection Results

▪ Kurt Vanderheyden ▪ Dec 11, 2019 @01:27 AM CST

Title: Beam Deflection Results

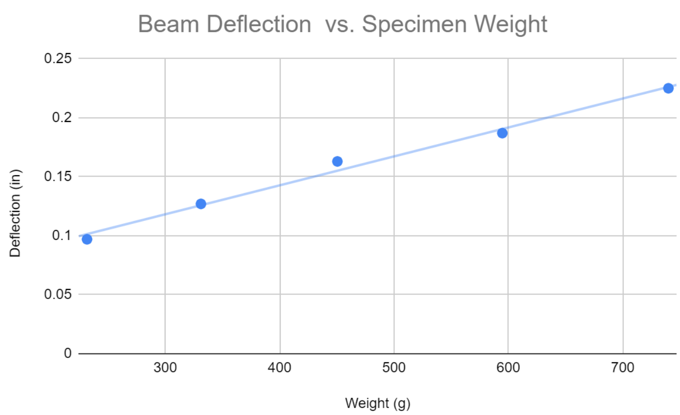
Date: December 11, 2019

Content by: Kurt V

Present: Whole Team

Goals: To record our testing results from applying different forces on the universal stage and measuring the deflection.

Content:



Beam Deflection vs Weight

Weight (g)	Deflection (in)
0	0
231.6	0.097
331.2	0.127
450.5	0.163
594.7	0.187
739.9	0.225
Linear Fit	.000245*x +.0446

The data provided shows the testing results for the beam deflection versus the application of different weights. There is also a linear fit to show how the deflection changed per gram of weight added to the universal stage.

Conclusions/action items:

A total of 5 different masses were added to the universal stage at increasing weights. The deflection and mass added showed a negative linear relationship with a linear fit equation of y=.000245*x+.0446 inches. This sounds like a small amount of deflection, but considering the average mass of rat that is used is between 250-500 grams, there would be noticeable deflection especially with larger specimen. The maximum weight that was used was 739.9 grams and this caused a deflection of .225 inches. This is above the average weight of a rat so it's unlikely that we would see this large of deflection in application of this stage in Dr. Rogers lab. The deflection of the rods could result in the eye not staying in the center of rotation as the different rotation elements are used. To combat the deflection, sturdier supports could be implemented in future designs and more weight being in the back to counter act the bending moment of the rods in the z axis.

12/11/2019 Alignment Time Results

• RILEY PIEPER • Dec 11, 2019 @01:26 AM CST

Title: Alignment Time Results

Date: 12/11/2019

Content by: Riley Pieper

Present: Full Team

Goals: Present the results of the testing conducted to determine how easy it is to move the specimens eye to the center of rotation and how much time this process adds to the imaging process in general, as the goal of this design is to streamline the imaging.

Content:

Find testing procedures for this experimentation in the protocols team folder

Alignment Time

Trial	Time (seconds)
1	76.8
2	43.02
3	82.2
4	37.98
5	66.6
6	70.2
7	38.46
Average	59.32
Standard Deviation	18.96

The table above presents the time required by 7 individuals to adjust the sample holder from a randomized position to where the eye of a stuffed animal (held in a pvc pipe taped to the universal stage) is aligned at the center of rotation using the aligner component fitted with retracting probes.

Stats:

Mean = 59.32 sec

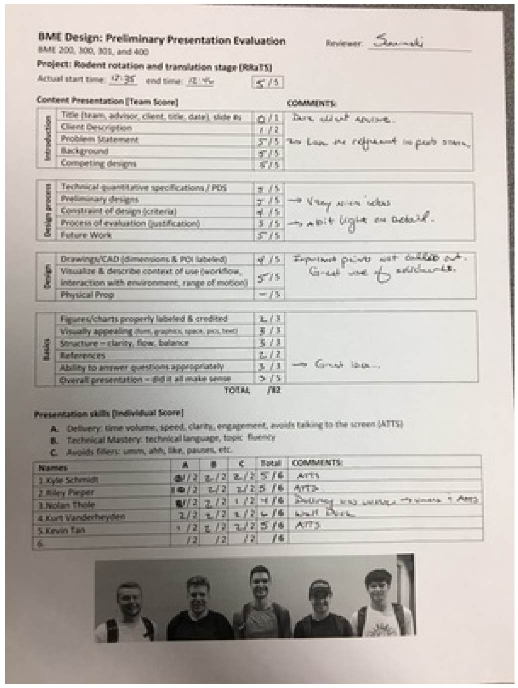
Standard Deviation = 18.96 sec

N = 7

Conclusions/action items: These results suggest that the aligner facilitates the aligning process and that it does not take a significant amount of time to align the eye at the center of rotation. Some things to consider provided these results include the fact that all seven of these replicates were inexperienced in adjusting the alignment of the imaged eye, so the time would likely go down with practice and acclimation to the device. Furthermore, it must be known that there was no way of telling whether the eye was directly at the center of rotation beyond visualizing the rods of the aligner, meaning the stopping point of each alignment may not have been exactly aligned.

Preliminary Presentation feedback

▪ NOLAN THOLE ▪ Oct 24, 2019 @10:09 PM CDT



BME Design: Preliminary Presentation Evaluation Reviewer: Sawicki
BME 200, 300, 301, and 400
Project: Rodent rotation and translation stage (RRaTS)
Actual start time: 12:35 end time: 12:46 5/5

Content Presentation [Team Score]

			COMMENTS:
Introduction	Title (team, advisor, client, title, date), slide #s	0/1	Done w/out advisor.
	Client Description	1/2	
	Problem Statement	5/5	[illegible]
	Background	5/5	
	Competing designs	5/5	
Design process	Technical quantitative specifications / PDS	3/5	
	Preliminary designs	5/5	→ Very nice ideas
	Constraint of design (criteria)	4/5	
	Process of evaluation (justification)	3/5	→ a bit light on detail.
	Future Work	5/5	
Design	Drawings/CAD (dimensions & POI labeled)	4/5	Important points not called out. Great use of [illegible].
	Visualize & describe context of use (workflow, interaction with environment, range of motion)	5/5	
	Physical Prop	– /5	
Basics	Figures/charts properly labeled & credited	2/3	
	Visually appealing (font, graphics, space, pics, text)	3/3	
	Structure – clarity, flow, balance	3/3	
	References	2/2	
	Ability to answer questions appropriately	3/3	→ Great idea...
	Overall presentation – did it all make sense	5/5	
	TOTAL	/82	

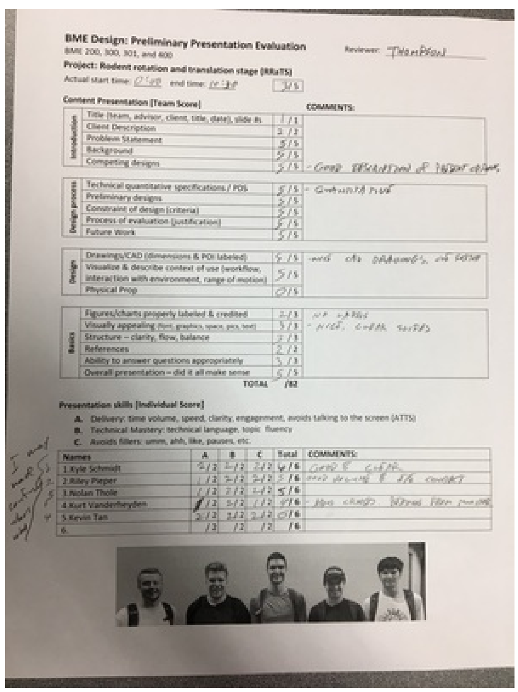
Presentation skills [Individual Score]

A. Delivery: time volume, speed, clarity, engagement, avoids talking to the screen (ATTS)
B. Technical Mastery: technical language, topic fluency
C. Avoids fillers: umm, ahh, like, pauses, etc.

Names	A	B	C	Total	COMMENTS:
1.Kyle Schmidt	[illegible]/2	2/2	2/2	5/6	ATTS
2.Riley Pieper	[illegible]/2	2/2	2/2	5/6	ATTS
3.Nolan Thole	[illegible]/2	2/2	1/2	4/6	Delivery was [illegible]
4.Kurt Vanderheyden	2/2	2/2	2/2	6/6	Well done
5.Kevin Tan	1/2	2/2	2/2	5/6	ATTS
6.	/2	/2	/2	/6	

A8D42911-35B5-415A-8FE7-0EC28BB7C2CA.jpg(151.4 KB) - download

▪ NOLAN THOLE ▪ Oct 24, 2019 @10:10 PM CDT



BME Design: Preliminary Presentation Evaluation Reviewer: Thompson
BME 200, 300, 301, and 400
Project: Rodent rotation and translation stage (RRaTS)
Actual start time: [illegible] end time: [illegible] 3/5

Content Presentation [Team Score]

			COMMENTS:
Introduction	Title (team, advisor, client, title, date), slide #s	1/1	
	Client Description	2/2	
	Problem Statement	5/5	
	Background	5/5	
	Competing designs	5/5	- Good description of [illegible]
Design process	Technical quantitative specifications / PDS	5/5	- Quantitative PDS
	Preliminary designs	5/5	
	Constraint of design (criteria)	5/5	
	Process of evaluation (justification)	5/5	
	Future Work	5/5	
Design	Drawings/CAD (dimensions & POI labeled)	5/5	[illegible] drawings, [illegible]
	Visualize & describe context of use (workflow, interaction with environment, range of motion)	5/5	
	Physical Prop	0/5	
Basics	Figures/charts properly labeled & credited	2/3	no labels
	Visually appealing (font, graphics, space, pics, text)	3/3	- nice, clear slides
	Structure – clarity, flow, balance	3/3	
	References	2/2	
	Ability to answer questions appropriately	3/3	
	Overall presentation – did it all make sense	5/5	
	TOTAL	/82	

Presentation skills [Individual Score]

A. Delivery: time volume, speed, clarity, engagement, avoids talking to the screen (ATTS)
B. Technical Mastery: technical language, topic fluency
C. Avoids fillers: umm, ahh, like, pauses, etc.

Names	A	B	C	Total	COMMENTS:
1.Kyle Schmidt	2/2	2/2	2/2	6/6	Good & clear
2.Riley Pieper	1/2	2/2	2/2	5/6	[illegible]
3.Nolan Thole	1/2	2/2	2/2	5/6	
4.Kurt Vanderheyden	[illegible]/2	2/2	1/2	4/6	- [illegible]
5.Kevin Tan	2/2	2/2	2/2	6/6	
6.	/2	/2	/2	/6	

02C4DC1B-B941-499D-906A-44B625FA5DEE.jpg(151.3 KB) - download

12/11/2019 Website Link

▪ RILEY PIEPER ▪ Dec 11, 2019 @01:07 AM CST

Title: Link to Team Project Website

Date: 12/11/2019

Content by: Riley Pieper

Present: Full Team

Goals: Link the website containing **all of the project files** completed by this team for this course.

Content:

http://bmedesign.engr.wisc.edu/projects/f19/rrats/

Items included on this page:

- Product Design Specifications
- Preliminary Presentation
- Preliminary Report
- Final Poster
- Final Report
- All Progress Reports

Conclusions/action items: Future teams working on this project can access the aforementioned files via this link in order to find information necessary for continuing the project.

9/19/2019 Rats - General Information

▪ RILEY PIEPER ▪ Sep 19, 2019 @04:43 PM CDT

Title: Rats - General Information

Date: 9/19/2019

Content by: Riley Pieper

Present: Riley Pieper

Goals: Learn, in general, the size of rats and mice that may inform elements of the design that may be used for holding said rodents for imaging purposes.

Content:

G. Musser. (2018, Oct. 10). *Rat* [Online]. Available: https://www.britannica.com/animal/rat

- 'rat' applies to various rodent families with bodies longer than 12 cm (5 in)
- most species weight about 95-240 g (3.4-8.5 oz)
- body length about 17-21 cm (6.7-8.3 in)

G. Musser (2019, May 16). *Mouse* [Online]. Available: https://www.britannica.com/animal/mouse-rodent

- 'mouse' applies to various rodent families with bodies less than 12 cm (5 in)
- larger end:
    - body length about 10-12 cm (4-4.7 in)
    - weight about 18 g (0.6 oz)
- smaller end:
    - body length about 6-8 cm (2.3-3.1 in)
    - weight about 3-12 g (0.11-0.42 oz)

Conclusions/action items: Our client did not specify a limit to the size of the stage design, as it does not need to fit into any particular space (rather, it will sit on a table near the imaging system). Due to this, the size constraint is the size of the actual specimens to be imaged. Thus, it is important to know these general metrics for the length and weight of mice and rats (two of the most common animal specimens used by our client), specifically in the design of the sample holder. We now know that the upper limit for the specimen size to be held is that of rats. Therefore, one of the interchangeable sample holders must be designed to accompany this large size, and the overall stage must accommodate the large size of this sample holder. Furthermore, the sample holder and the overall design must be strong enough to hold the maximum weight of the specimen (taking into account a factor of safety). It was clear from analysis of previous work on this project that the magnetic attachment of the sample holder did not provide the necessary support for the weight of a rat, especially is the support is not directly under the holder's center of mass. This is a clear place where our team's design should be improved upon.

10/7/2019 Rodent Eye Features

▪ RILEY PIEPER ▪ Oct 07, 2019 @10:04 AM CDT

Title: Rodent Eye Features and Dimensions Research

Date: 10/7/2019

Content by: Riley Pieper

Present: None

Goals: Learn about the size and dimension of the rodent eye, specifically relating to the retina, in order to develop conclusions about the adjustment freedom required to image the full scope of the retinal cells.

Content:

Y. Geng, K. P. Greenberg, R. Wolfe, D. C. Gray, J. J. Hunter, A. Dubra, J. G. Flannery, D. R. Williams, J. Porter, "In vivo imaging of microscopic structures in the rat retina," *Invest Ophthalmol Vis Sci,* vol 50, no 12, pp. 5872-5879, Dec, 2009.

- study conducted on Sprague Dawley rats
- in vivo resolution in the rat eye could be twice that of the human eye because of the large numerical aperture
    - aperture of rats was about 0.43
    - subcellular features can be resolved with AO (adaptive optics)
- motivation: studies of rodent disease (that can be extrapolated to similar ocular disease in humans) often relies on 'histopathology'
    - histopathology yields high-resolution images
    - allows for morphometric estimates of *surviving* retinal cells
    - does not allow for longitudinal studies in the same animals
    - in vivo imaging allows for visualization of disease **over time**
- Eye metrics across species:
    - Average axial length (front to back)
        - human: 23.5-24 mm
        - rat: 6.1 mm
        - mouse 3.3 mm
    - Numerical aperture
        - human: 0.2
        - rat: 0.43
        - mouse: 0.49
- retinal spatial to angular conversion of rat eye: 58.1 um/deg
    - images collected over either 3 degree of 4.7 degree FOV
    - physical width of 174.3 um or 273.1 um respectively

Conclusions/action items: I was hoping to read this paper and learn more about the spacial dimensions of the retina within the rodent eye, specifically relating to the angular range that it covers on the posterior surface of the inner eye. However, this paper only reported the angular FOV that *they* imaged, which is not necessarily the entirety of the retina. Even so, this value of FOV may lend itself to our understanding of the necessary angular resolution required. After speaking to our client, we are interested in developing angular adjustment with a precision of about 2 degrees. This paper somewhat confirms this metric, due to the fact that the field of view for imaging rodents in a similar way is around twice that. This makes sense, due to the fact that various images taken across the retina must be correlated and patched together. This article was particularly interesting in providing information relating to the motivation behind imaging rodent eyes in vivo (within living rats) - the ability to visualize the evolution of ocular disease in the same subject over time. It provided information relating to the connection between human/rodent eyes as well as why rodent eyes are easier to image. With the preliminary report around the corner, I will use this information to provide context relating to the application of the design as it relates to the study of rodent ocular diseases and the motivation for this research.

10/8/2019 Client Research Motivation

▪ RILEY PIEPER ▪ Oct 08, 2019 @06:24 PM CDT

Title: Client Research Motivation Information

Date: 10/8/2019

Content by: Riley Pieper

Present: None

Goals: Learn more about the specific research conducted by Dr. Rogers and Dr. Sajdak and the implications of the project that we are working on for them.

Content:

J. D. Rogers. *Rogers Lab: Biomedical Optics and Biophotonics.* [Online]. Available: https://loci.wisc.edu/rogers/

Current Research Projects in Dr. Roger's Lab

- Quantification of lipofucsin autofluorescence spectral changes in age-related macular degeneration
- Imaging metabolic activity in differentiating retinal stem cells in vitro
- optical metrology of scattering properties of tissue

D. Gamm. *McPhearson Eye Research Institute: About.* [Online]. Available: https://vision.wisc.edu/about/

Broad Applications via the McPhearson Eye Research Institute

- use of imaging to contribute to the prevention and treatment of blinding diseases
- millions of Americans, including 100000 WI residents, suffer from:
    - macular degeneration
    - glaucoma
    - diabetic retinopathy
    - childhood-onset disorders
    - many other conditions

Specific Disorders:

American Macular Degeneration Foundation. *What is Macular Degeneration?* [Online]. Available: https://www.macular.org/what-macular-degeneration-alt?utm_expid=.U-NbhAQoTROx5WyrxrLxPQ.1&utm_referrer=https%3A%2F%2Fwww.google.com%2F

Macular Degeneration:

- leading cause of vision loss affecting more than 10 million Americans
    - more than cataracts and glaucoma combined
- currently an **incurable** eye disease
- caused by deterioration of central portion of the retina
    - macula is the central portion of the retina
    - macula is responsible for focusing central vision in the eye
    - plays a role in:
        - reading
        - driving
        - recognition
- people with very advanced macular degeneration are considered legally blind
- two types:
    - dry macular degeneration (85-90%)
    - wet macular degeneration (10-15%)
- three stages:
    - early age-related macular degeneration
        - most do not experience vision loss
        - diagnosed by presence of medium-sized drusen
            - drusen are yellow deposits beneath the retina
    - intermediate AMD
        - some vision loss may be present
            - some still have no noticeable symptoms
        - eye exams look for larger drusen or pigment changes in the retina

    - late AMD
        - vision loss has become noticeable
- **specific factors causing macular degeneration are not conclusively known**
    - **limited by insufficient funding**
    - **causes thought to be both hereditary and environment**
- **there is currently no known cure of macular degeneration**

K. Boyd. (2019, Aug 28). *What is Glaucoma?* [Online]. Available: https://www.aao.org/eye-health/diseases/what-is-glaucoma

Glaucoma

- disease due to optic nerve damage
- fluid builds up in the front of the eye causing an increase in pressure that can damage the nerve
- **leading cause of blindness in people over 60 years old**
- two major types:
    - Primary Open-Angle Glaucoma
        - most common type
        - happens gradually when eye does not effectively drain fluid
        - painless and causes no vision changes at first
        - some people have optic nerves that are sensitive to normal eye pressure
            - important to regularly get examined for nerve damage
    - Angle-Closure Glaucoma
        - person's iris is very close to the drainage angle of the eye
            - iris ends up blocking the drainage
        - eye pressure increases very quickly - called an acute attack
        - some people develop angle-closure glaucoma slowly
        - can result in severe eye pain
        - can cause blindness if not immediately treated

Conclusions/action items: There are clearly a number of ocular diseases that are detrimental to patients suffering from them. Our client, Dr. Rogers evidently conducts his imaging research on the eyes of rodents to gain insight about the eye and the retina in order to provide information that could lead to the treatment of diseases alike Age-Related Macular Degeneration and Glaucoma. Based on the information provided by the McPhearson Eye Research Institute, there is a lot of research being conducted by the University of Wisconsin in this area. Not to mention the fact that this research is in high demand, as macular degeneration currently has no cure. For these reasons, creating an adjustable stage to facilitate the imaging of specimen eyes by both Dr. Rogers and other researchers that may use our design would indirectly contribute to the furthering of research that will ultimately lead to effective treatments of these diseases so that less people across the world will have their sight permanently taken from them. The information provided in these research notes can be used as background information in future presentations and reports to give an overview of the type of research that our client is conducting and that our design will be used in tandem with. Furthermore, the social impact of the research that our design will be used in is an important component of the story that we hope to tell by the end of the design process in terms of the broader implications and impacts that our hard work can have.

9/19/2019 Bioptigen RAS Patent

• RILEY PIEPER • Sep 19, 2019 @04:26 PM CDT

Title: Bioptigen RAS Patent

Date: 9/19/2019

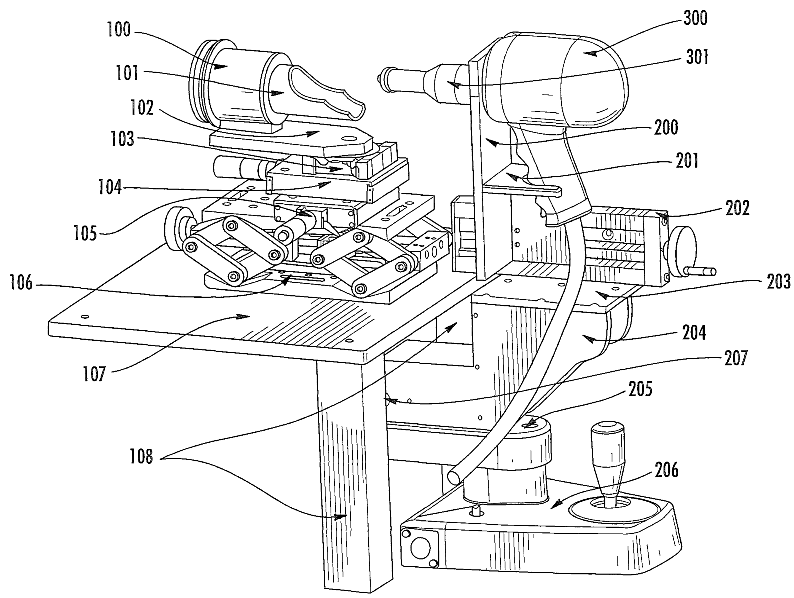
Content by: Riley Pieper

Present: Riley Pieper

Goals: Read the patent awarded to the primary competing design: the Bioptigen RAS, to learn of any general ideas that our team can build from and implement to our design. Furthermore, learn about the specific intellectual property associated with the patent of this design.

Content:

S. Sayeram, J.E. Vance, P. Huening, E.L. Buckland, J.A. Izatt, G.A. Myers, "Systems for imaging structures of a subject and related methods," U.S. Patent 8 721 080 B2, May 13, 2014.



- overall system patented - includes imaging device with a related holder providing two translational DOF
- subject mount structure provides two rotational DOF
- allows for the positioning of the specimen (eye) at the intersection of the two rotational axes and the optical axis of the imaging instrument.
- specimen holder contains a bite-bar for specimen positioning with a translational and elevational axis
- specimen holder integrates flow tubes for the heating of the specimen during imaging
- two rotational degrees of freedom:
  - yaw achieved via the pivot below the specimen holder
  - roll achieved via the concentric cylinders allowed to rotate
  - pitch not achieve with this design

Conclusions/action items: This patent focuses its claims on the ability to gain rotational freedom during the imaging of eyes by positioning the pupil at the intersection of the rotational axes. However, this invention does this, in part, via the translational degrees of freedom provided to 'structure 2' intended to hold the imaging apparatus. Our team intends to accomplish similar functionality with our design. However, due to the fact that the imaging system that our client uses will not be moveable, our single-structured design must provide both the necessary rotational degrees of freedom and the translational degrees of freedom. One interesting element of this design is the translational degrees of freedom provided to the bite bar intended to hold the animal subject in place during imaging. This bite bar is allowed to translate side-to-side and elevate. As our team begins to develop our design, we should continue to reference this patent for ways to achieve various degrees of freedom. Furthermore, if, down the road, the team decides to pursue a patent for our design, we must keep in mind the claims made by Bioptigen here. Moving forward, my team members and I will commence brainstorming individual designs. We may use the information provided in this patent to spark ideas for our brainstormed designs.

9/24/2019 Optics Focus 5-Axis Motorized Stage

• RILEY PIEPER • Sep 24, 2019 @11:20 PM CDT

Title: 5-Axis Motorized Positional Stage

Date: 9/24/2019

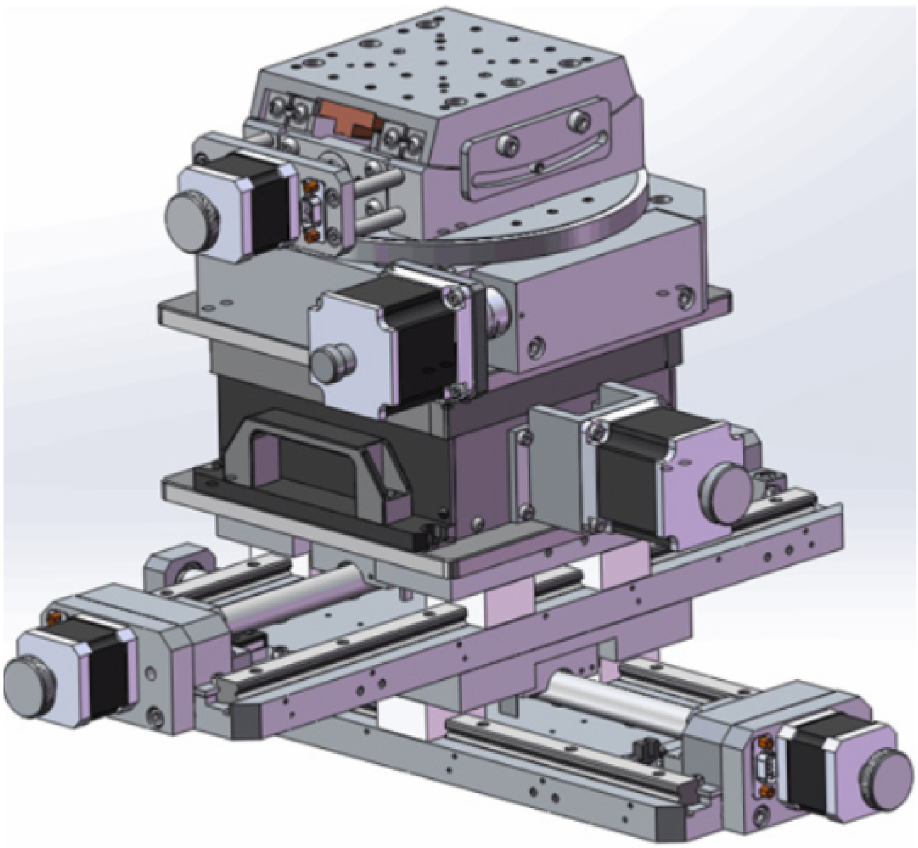
Content by: Riley Pieper

Present: None

Goals: Explore another design on the market that is similar to the application we are targetting. Extrapolate the beneficial components to this product and note the potential drawbacks that can be implemented into our design or improved upon, respectively.

Content:

Optics Focus. (2019). *5-Axis Motorized Positional Stage.* [Online]. http://www.optics-focus.com/5axis-motorized-positioning-stage-p-1141.html



- price = $6232 is significantly over budget
    - likely due, in part, to the motorized components (electronics)
- provides 5 degrees of freedom
    - x and y translation
    - z translation
    - rotating stage
    - goniometer (pitch or yaw, depending on rotating position)
- load center capacity - 10kg
- motorized adjustment in all degrees of freedom
- adjustment resolution:
    - XY - 3.125 microns
    - Z - 0.5 microns
    - rotating stage - 0.00125 deg
    - goniometer - 0.0005357

After some searching, by name of the product and of the company providing it, I was unable to find a patent filed for this product.

Conclusions/action items: Primarily, it is clear that this design is significantly too expensive for the budget set by the client. For this reason, it is unlikely that our team will be able to reproduce the same alignment resolution with all the same features. However, some of the components seem to be especially beneficial and may be applied to our design, especially including the goniometer to add a rotational degree of freedom. As depicted in the inserted picture, the rectangular stage has a curved bottom that can slide along a curved surface to rotate. This may be a beneficial way to achieve rotational adjustment without the need for the gear system utilized by the previous team (would be easier to clean/sterilize a smooth surface). Finally, the motorized components for the adjustment of the stage clearly increase the ease of use and could be somethat that our team considers once further along the way with a design idea. At this point, I will continue to research competing designs (as well as physiological research) and begin brainstorming design ideas based on what I learn for this. Members of the team are planning on meeting and sharing a personal design idea that we will analyze and evaluate.

9/24/2019 ThorLabs 5-Axis Stage

• RILEY PIEPER • Sep 24, 2019 @11:34 PM CDT

Title: Compact 5-Axis Pitch, Yaw, and Translation Stage

Date: 9/24/2019

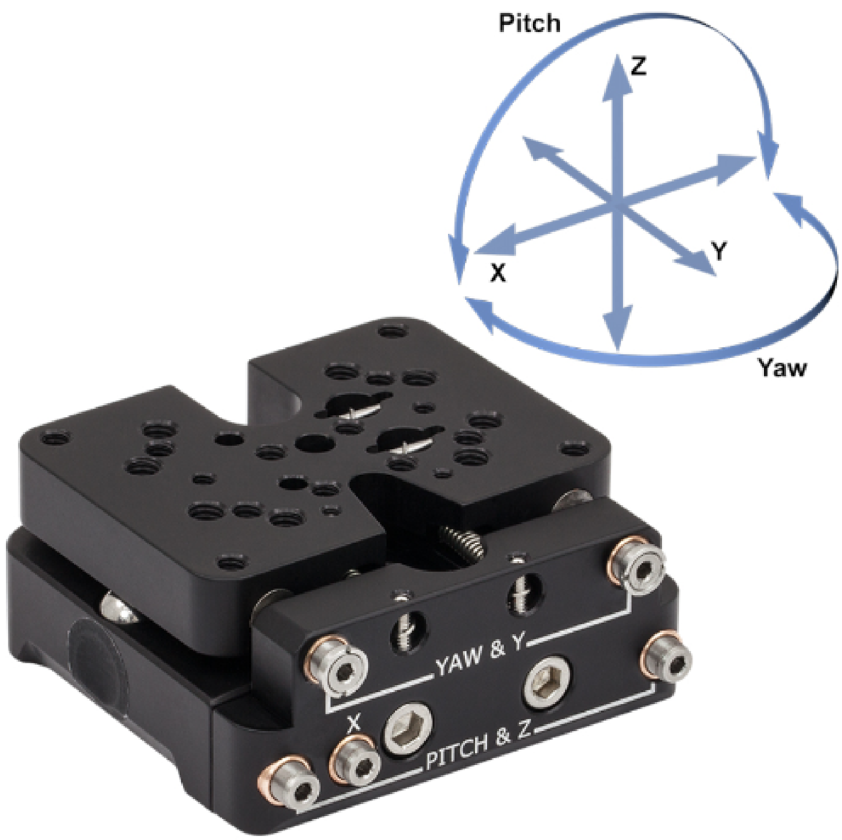
Content by: Riley Pieper

Present: None

Goals: Continue research into relevant products that are similar or relate to our design aims. Document the primary components of a design presented by ThorLabs and weigh the pros and cons.

Content:

ThorLabs. (2019). *Compact 5-Axis Pitch, Yaw, and Translation Stage.* [Online]. https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=7850



- price is around $422.24 which is much more reasonable in terms of the budget awarded to us
- adjustment degrees of freedom:
    - X - linear translation
    - Y - linear translation
    - Z - linear translation
    - pitch
    - yaw
- contains threaded mounting holes on the surface that translates for attachment

Conclusions/action items: Moving forward into the brainstorming and design phase, I will reference this design for beneficial components that could be implemented into our design. Some such elements include the fact that the surface employs a number of holes that would allow for mounting of components on it. This reminds me of the mounting done on an optical breadboard and would be useful for the flexibility of changeable sample holders. On the other hand, it is clear that this design does not feature an accessible intersection between rotational axes which is key to our design. If more information about this product is desired in the future, it can be accessed via this entry.

12/10/2019 Defining Rotation

• RILEY PIEPER • Dec 10, 2019 @06:45 PM CST

Title: Defining Rotation

Date: 12/10/2019

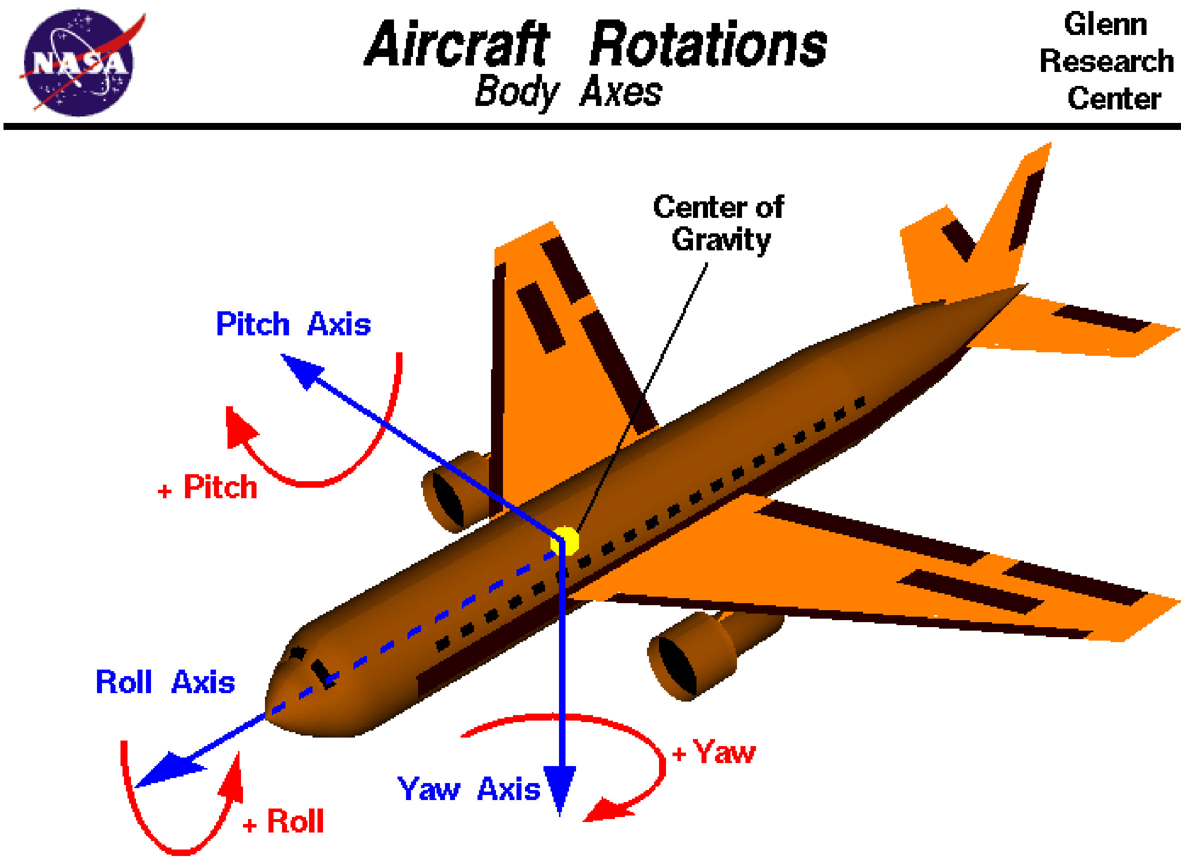
Content by: Riley Pieper

Present: None

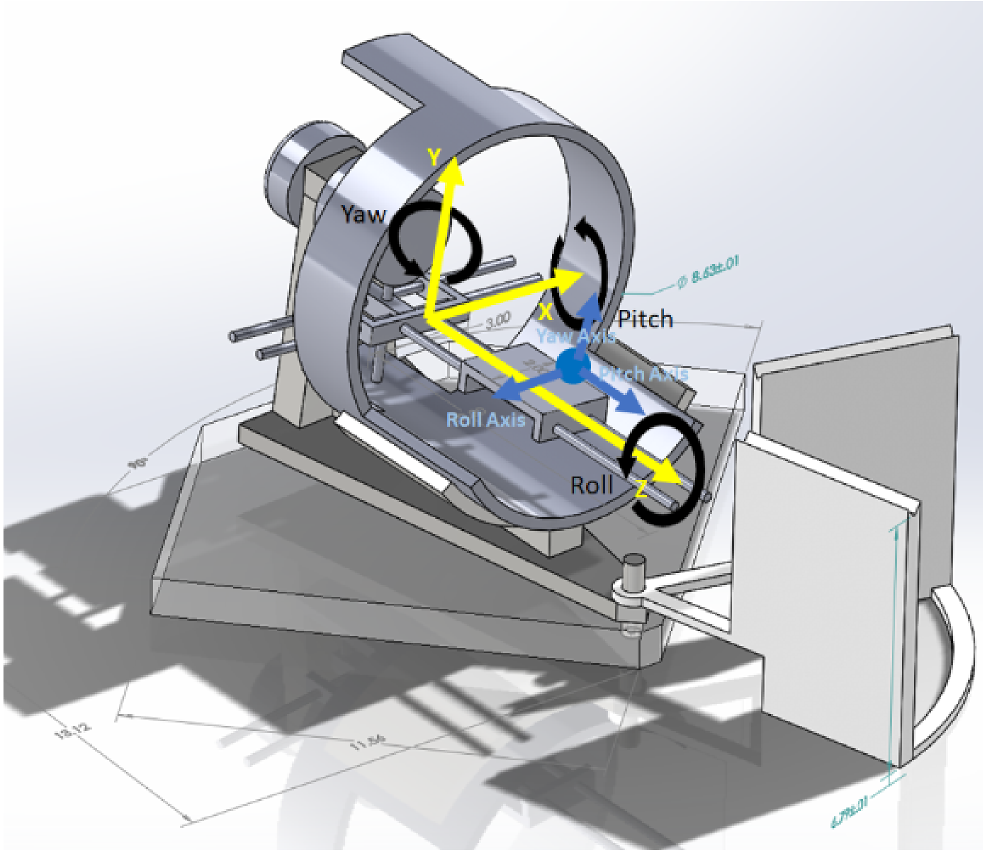
Goals: Discern the correct rotational axis designation in order to correctly define them and mention them in the context of our design for the final report.

Content:

N. Hall. (2015, May. 5). *Aircraft Rotations* [Online]. Available: https://www.grc.nasa.gov/www/k-12/airplane/rotations.html



- rotational degrees of freedom defined according to an aircraft
- Defined with respect to the front of the plane:
    - Roll is along the axis parallel to the body of the plane
    - Pitch is along the axis pointed along the wings
    - Yaw is along the axis pointed perpendicular, towards the ground
- Cartesian translation axes not presented in this diagram
    - axes defined as roll, yaw, and pitch axes corresponding



- Compare eye of rat sitting on the stage (being imaged) to the aircraft to define axes
  - "roll axis" points out directly towards the camera
  - "pitch axis" points perpendicular, parallel to the ground
  - "yaw axis" points perpendicular to both, up and down from the center of the eye
- Rotational DOF of the *rat* is slightly different that that of the eye (the rat eye is on the side of its head, so two of its axes are switched)
  - "roll" points along the body of the rat (perpendicular to roll axis of the eye, parallel to pitch axis of the eye)
    - roll of the rat is pitch of the eye
  - "pitch" points outward from the rat, parallel to the ground
    - pitch of the rat, is roll of the eye (roll of the eye is unnecessary for this design project, according to the client)
  - "yaw" is the same axis as yaw of the rat eye (pointing up and down)
- **Because roll, pitch, and yaw are defined according to their own, specially named axes, x, y, and z, linear axes can be defined independently**
- defining these linear axes is only crucial to the internal translation, therefore only necessary to define with respect to the full rodent
  - Z - along the body of the rat (same as roll axis of the rat)
  - Y - up/down from the rat (same as yaw of the rat/eye)
  - X - side-to-side from the rat (pitch of the rodent)

Conclusions/action items: These axes definitions and rotational degrees of freedom discussion will be implemented into diagramming the final design prototype for the final report. Agreement among discussion of the degrees of rotation provided and adjusted is necessary for full understanding of the functionality of our design and for replicability of our design if it is to be reproduced or if future work is to be conducted on it. These axes definitions will be clearly discussed in the final report and represented to eliminate any confusion that may have arisen during explanation of our design and poster during final poster presentations.

9/24/2019 Intersection Alignment Guide

▪ RILEY PIEPER ▪ Oct 03, 2019 @09:12 AM CDT

Title: Intersection Alignment Guide Ideas

Date: 9/24/2019 (NOTE: edited on 10/3 to add template elements)

Content by: Riley Pieper

Present: None

Goals: Brainstorm conceptual ideas for design elements that could be useful in aligning the pupil of the subject's eye at the center of the intersection of the rotational axes.

Content:

- add **lasers** pointing down each rotational axis on either side to clearly pinpoint the intersection between these axes
- lasers would allow the precise alignment of the specimen's eye at this intersection point
    - the design will include translational freedom within the rotational adjustment
    - translation in this fashion will be conducted during the staging process, lasers will ensure (relatively) accurate alignment of the eye during this staging

- do the lasers need to have calibration capabilities?
- would they be battery powered? how would they be turned on? (do they need to be interconnected to turn on at once?)
- are all lasers only visible at the point at which they point or is the line of action also visible?

Conclusions/action items: I will share this potential idea with my other team members to see if they have any thoughts or subsequent ideas that they can build from this. Furthermore, I should conduct research into the interaction between lasers and the rodent subject's eye (will this damage their eye or be detrimental to the ultimate image being taken?) When I begin to draw up designs, I will consider implementing this component into the structure of the design and consider how this element contributes to the effectiveness of our design in meeting our product design specifications. If the group decides to move forward with this idea, we must look into the pricing and quality of lasers to acquire for a prototype design, as they must fit into to budget set by our client.

9/24/2019 Rotational DOF - 'Russian Doll'

▪ RILEY PIEPER ▪ Oct 03, 2019 @09:18 AM CDT

Title: Rotational DOF - 'Russian Doll' Design Idea

Date: 9/24/2019 (NOTE: edited on 10/3 to add template elements)

Content by: Riley Pieper

Present: None

Goals: Document the idea I have been brainstorming that aims to provide rotational degrees of freedom (this is not a full design, but the portion of the design that allows rotational adjustment).

Content:

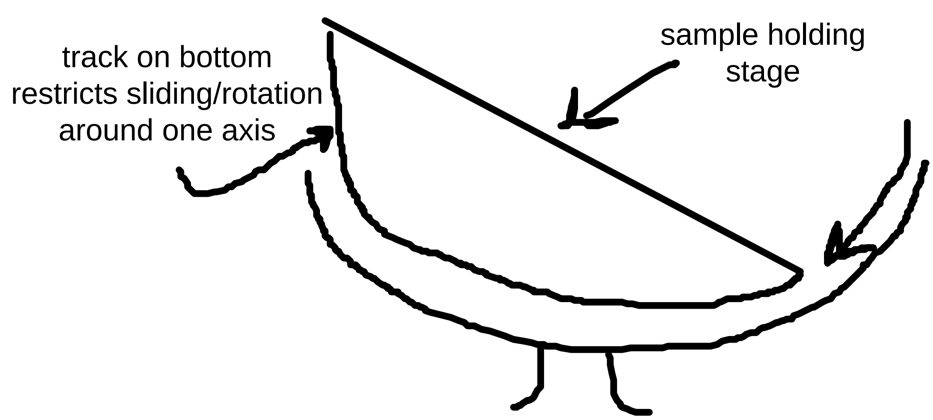
See drawing below.

- rotational components would be composed of concentric, sliding, partial spheres that fit within one another, alike Russian nesting dolls
    - each sphere would have a track that travels along a crevice in the previous (larger) sphere
    - each sphere will only provide one degree of rotational freedom
- idea coming from the concentric cylinder component of the RAS competing design
- would likely be composed of 3 concentric spheres
    - smallest (top) would rotate, sliding up/down on larger sphere
    - middle would rotate, but restricted to the perpendicular direction to previous
    - largest (bottom) would spin to provide final DOF

- is there a benefit to including the sphere or would this work with crescent tracks only?

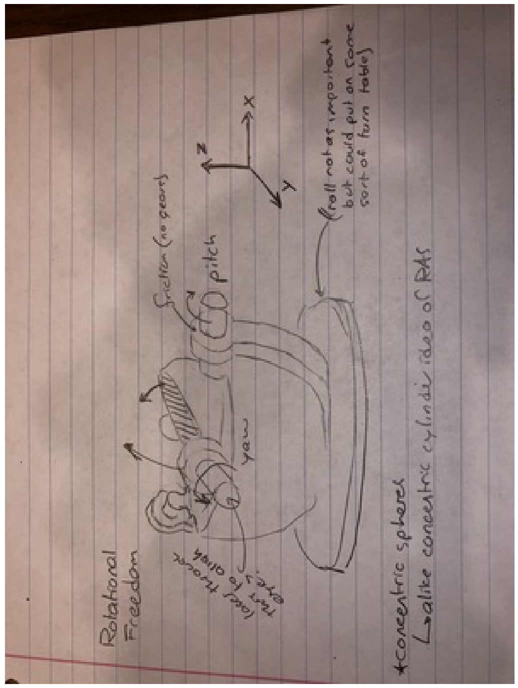
Conclusions/action items: Share this design idea with other team members and get their thoughts on the design concept. I will take this design idea and draw it up more specifically with SolidWorks in the near future to get a better idea of how such a structure would need to be constructed. This design will likely be a portion of one, if not multiple of my individually presented designs to my group. However, this element still requires additional components to provide the internal translational degrees of freedom. I will brainstorm how to design these elements as well as how to implement the various elements together.

▪ RILEY PIEPER ▪ Sep 24, 2019 @11:50 PM CDT



9/27/2019 Concentric Spheres

▪ RILEY PIEPER ▪ Sep 27, 2019 @07:51 PM CDT



4153596F-8C96-469C-A60E-812176AE4EDC.jpg(429.6 KB) - download

▪ RILEY PIEPER ▪ Oct 03, 2019 @09:27 AM CDT

Title: Concentric Spheres Design Idea (Drawing)

Date: 9/23/2019 (NOTE: edited on 10/3 to add template elements)

Content by: Riley Pieper

Present: None

Goals: Document a more detailed/explained design idea utilizing the 'Russing Doll' concentric sphere idea presented in a previous entry.

Content:

See attached image of hand-drawn design idea.

- two perpendicularly attached concentric partial spheres roll past one another, providing roll and pitch
- entire design component spins, providing yaw
- contact within the connection points of each sphere provides friction staying force that holds the stage at the desired rotational position
- rotational axes are perpendicular and intersecting

Conclusions/action items: Create a more detailed presentation of this design idea in Solidworks, considering more specific dimensions to present to the group. Translational components must be implemented into this design to align the ultimate sample holder on the stage such that the subject's pupil is centered at the intersection of the rotation axes. If a friction-based design alike this ends up being chosen by the team, we will need to research materials that provide the right amount of friction such that the design will be rotatable, yet stay in place, even with the weight of a rat supported. This design, however, is successful in achieving smooth surfaces that allow for facile sanitization.

10/1/2019 Big Bowls SolidWorks

▪ RILEY PIEPER ▪ Oct 03, 2019 @11:05 AM CDT

Title: Big Bowls Design Idea (SolidWorks)

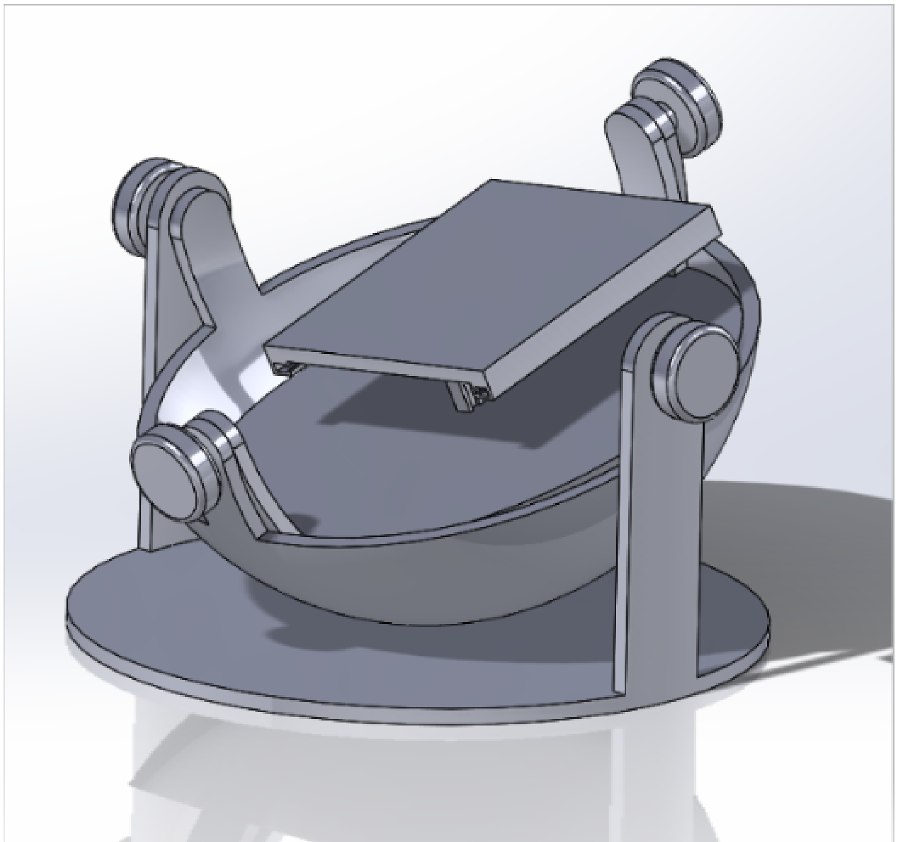
Date: 10/1/2019 (NOTE: edited on 10/3 to add template elements)

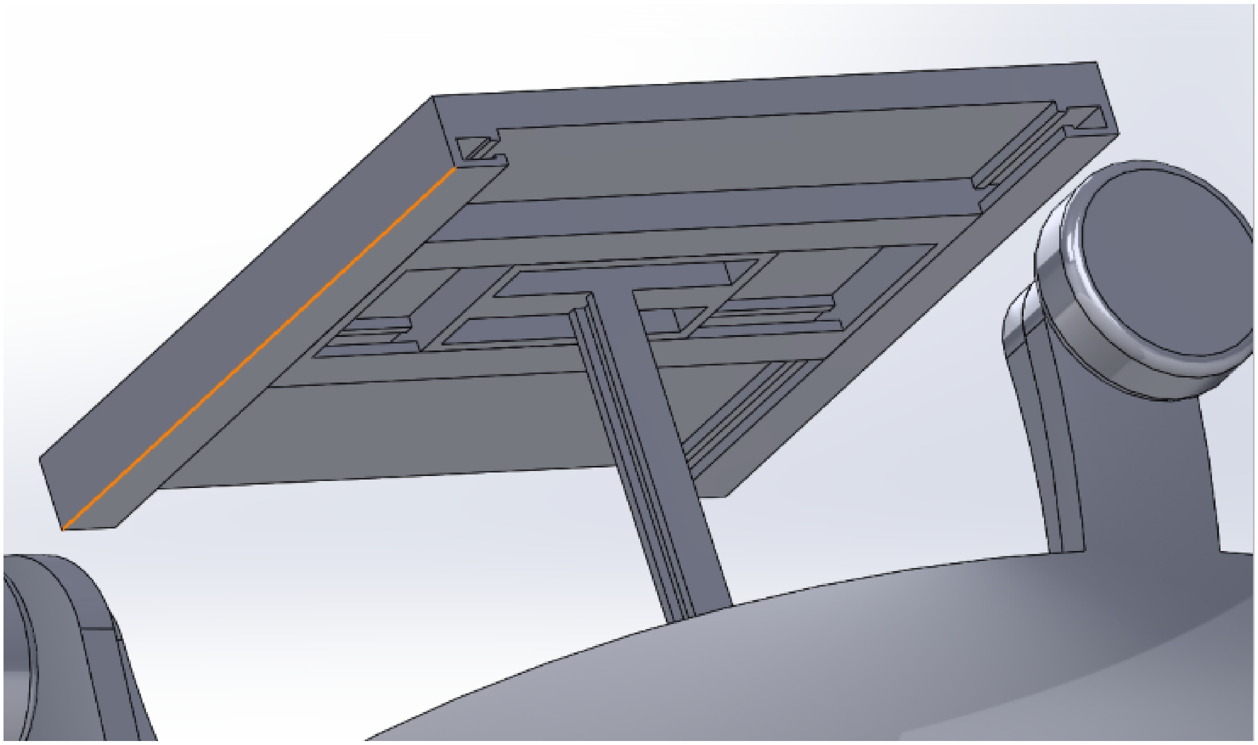
Content by: Riley Pieper

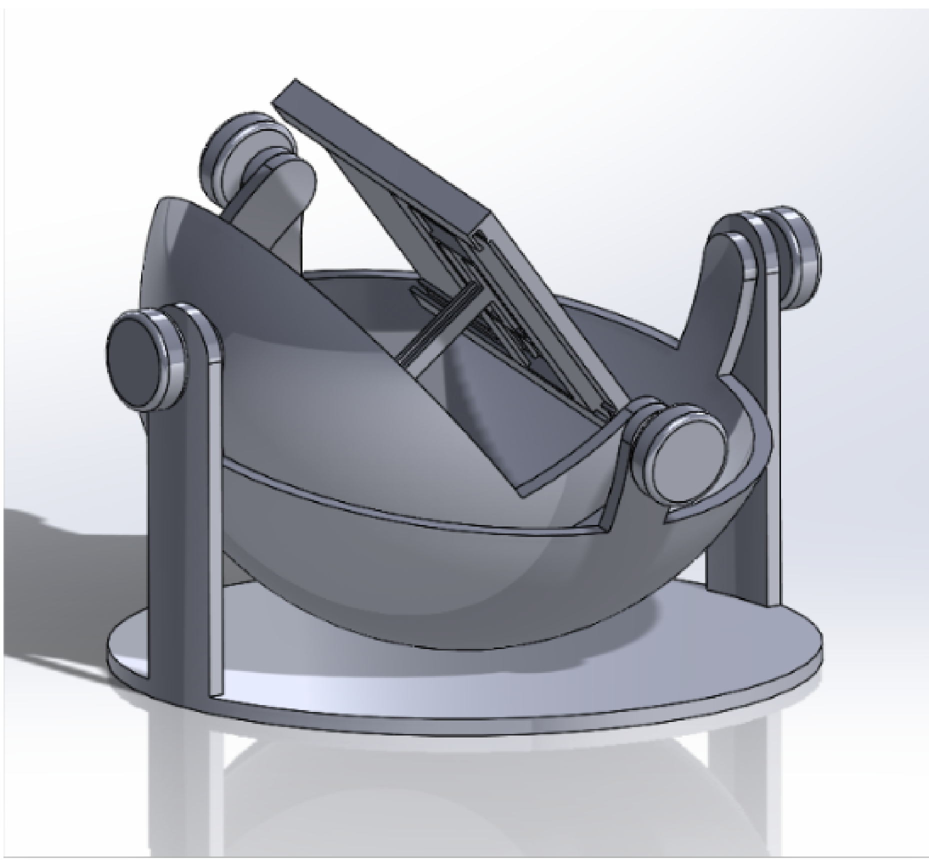
Present: None

Goals: Document the Solidworks drawings that I created to develop a more thoroughly thought-out design that I brainstormed in an earlier entry, utilizing concentric spheres to provide rotational freedom.

Content:







Conclusions/action items: I will present this design idea to my group and potentially use it as a design alternative in our preliminary design presentation. This design seems to successfully allow for rotational freedom in two perpendicular axes, yet is missing one of the crucial axes of rotation: yaw. In order to achieve this, an element must be added in order to 'spin' the entire structure. Only one of the rotational axes provided here is required by the client, so it may be beneficial to add the spinning and remove one of the present rotations here. One concern of mine is the fact that the dials may block the view of the subject in certain configurations. The translational stage here also utilizes friction to move and stay in place - the z-axis, however, needs an element to fix it in place as friction may not be strong enough to hold weight. The stage itself needs connection portions to mount interchangeable sample holders as well. This design builds off of preliminary designs but should be updated and refined before presenting such that it meets the needs of the client to the best of our ability.

▪ RILEY PIEPER ▪ Oct 01, 2019 @07:13 PM CDT

Base.SLDPRT(92.6 KB) - download

▪ RILEY PIEPER ▪ Oct 01, 2019 @07:13 PM CDT

BigBowls.SLDASM(267.5 KB) - download

▪ RILEY PIEPER ▪ Oct 01, 2019 @07:13 PM CDT

InnerBowl.SLDPRT(151.9 KB) - download

▪ RILEY PIEPER ▪ Oct 01, 2019 @07:13 PM CDT

OuterBowl.SLDPRT(223 KB) - download

▪ RILEY PIEPER ▪ Oct 01, 2019 @07:13 PM CDT

TransBox.SLDPRT(105.3 KB) - download

▪ RILEY PIEPER ▪ Oct 01, 2019 @07:13 PM CDT

TransColumn.SLDPRT(100 KB) - download

▪ RILEY PIEPER ▪ Oct 01, 2019 @07:13 PM CDT

TransPlate.SLDPRT(84.3 KB) - download

10/2/2019 Big Bowls (Updated)

▪ RILEY PIEPER ▪ Oct 03, 2019 @12:12 PM CDT

Title: Big Bowls Design Idea (SolidWorks) (Updated)

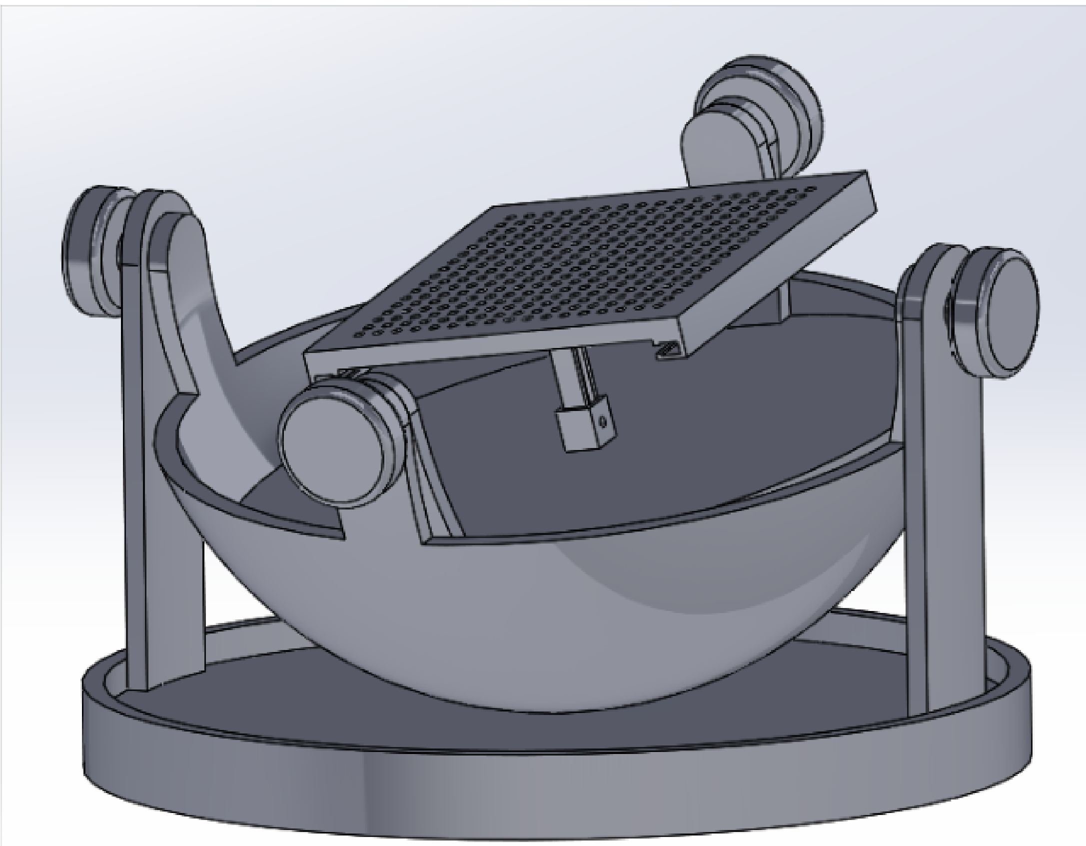
Date: 10/3/2019 (NOTE: edited on 10/3 to add template elements)

Content by: Riley Pieper

Present: None

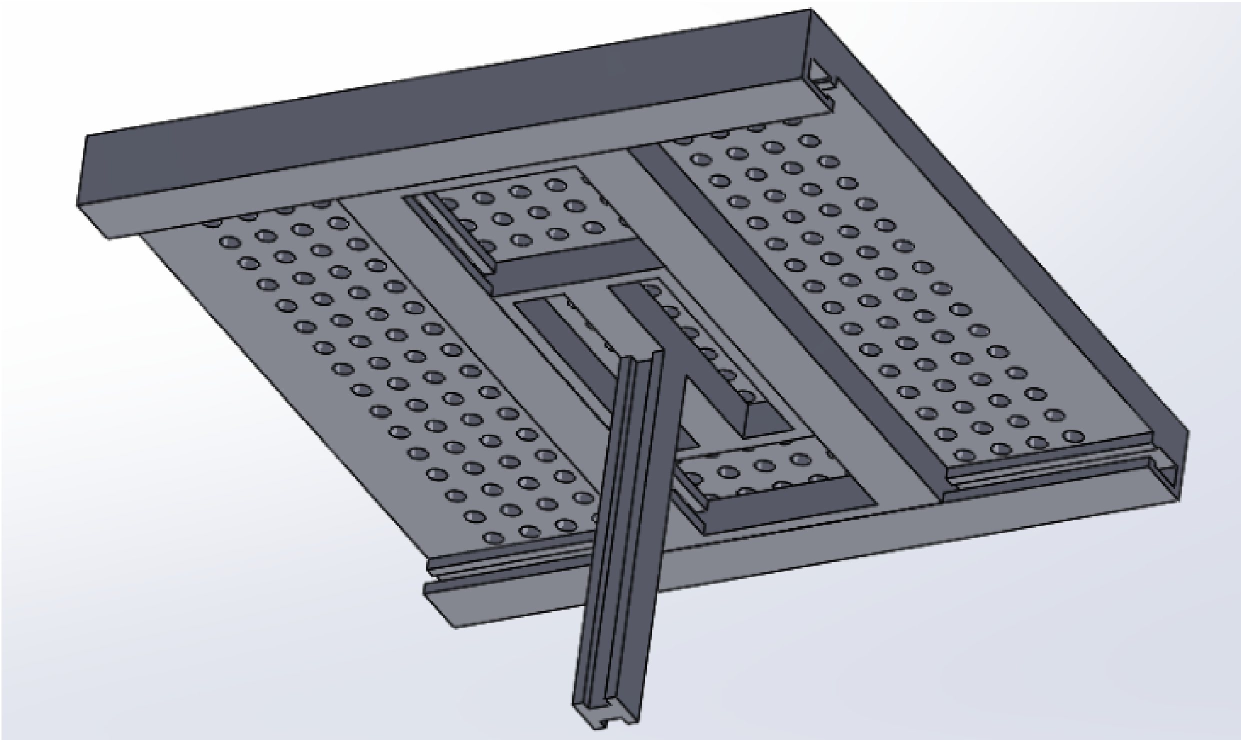
Goals: Update the Solidworks drawing design that was documented in a previous entry to fully achieve the requirements of the client, specifically related to the mounting of a sample holder and the third necessary rotational degree of freedom.

Content:



Full Big Bowls preliminary design

- features pitch and roll degrees of freedom via concentric bowls that rotate with friction past one another
- bowls are held at the angle of rotation via friction, adjusted with knobs on either side
- internal translation conducted via translational plate (imaged below)
    - internal translation also positioned via friction
    - vertical (Z) translation held in place with a tightened bolt at base
- yaw rotation via entire design spinning on the ball-bearing bottom cylinder portion



Internal translational stage component - underside view:

- features tracks for translation in all three linear directions
- stage itself features breadboard-like holes for attachment of various sample holders

Conclusions/action items: This design will be presented as an alternative design in our preliminary presentation. It provides six degrees of freedom (three rotational and three translational), yet could improve by specifically adding three additional translational degrees of freedom of the entire unit (external translation) - even though this may be accomplished by the cart that it is placed upon (that will be moved to the front of the optical board with the imaging system). This design utilizes friction for the movement and stability along each of the degrees of freedom. This may be improved by adding physical dials that precisely alter the internal translational position of the sample holder. The team should also begin brainstorming rough ideas for the sample holder that could be added to this translational stage to hold the actual specimens (multiple sample holders will be necessary). Finally, this design, and those of my teammates should be evaluated against one another according to the design matrix criteria. The most effective design will be chosen and determined to move forward with.

10/3/2019 Pizza Design

▪ RILEY PIEPER ▪ Oct 03, 2019 @09:35 PM CDT

Title: Pizza Design (SolidWorks Image)

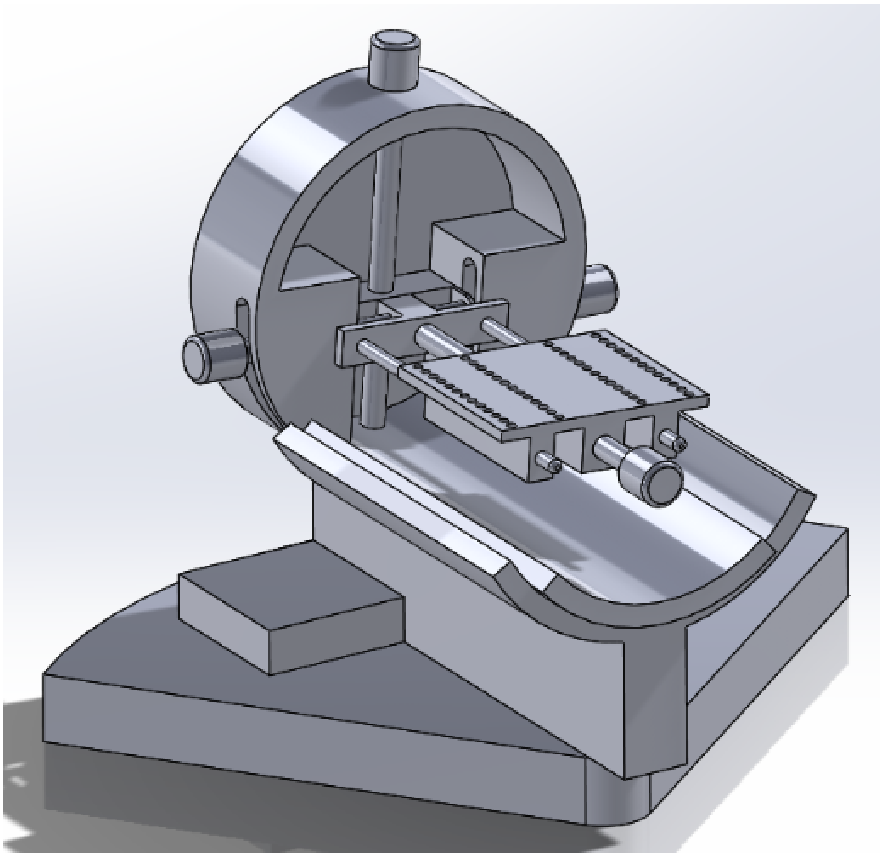
Date: 10/3/2019

Content by: Riley Pieper

Present: None

Goals: Document the 'Pizza' design idea, via the SolidWorks drawing, that will be evaluated in the design matrix alongside the Bowls design and any other team member designs.

Content:



- 5 degrees of freedom
- Rotational Adjustment - Friction
    - Cylinder - Pitch
    - Pivot - Yaw
- Internal Translation
    - Precise Dial Alignment
    - Travel Along Threaded Rods

Conclusions/action items: This design seems the be the most optimal for solving the design problem yet. It has eliminated the unnecessary degree of freedom in support of simplicity and ease of adjustment. Furthermore, its implementation of threaded rods for internal translation adjustment will allow for more fine adjustment of the pupil such that it is at the center of the rotational axes. This design will be presented during our preliminary presentation. If, as it seems, this design is determined to be the most successful of the preliminary designs, it will be moved forward with. On this note, we will receive feedback from our client and advisor on their concerns about the design and any improvements that can be made. At this point, it may be beneficial to implement a laser (as previously suggested) or sight system to facilitate pupil alignment. Furthermore, I must consider how this design will integrate with a cart to provide the necessary external degrees of freedom as it is positioned near the imaging system. Finally, if we decide to move forward with this design, I will begin brainstorming ways to fabricate its elements. As this is a SolidWorks design, I will be able to conduct some testing computationally, if necessary.

10/18/2019 Positioning Rods Component

• RILEY PIEPER • Oct 18, 2019 @01:28 PM CDT

Title: Positioning Rods Component

Date: 10/18/2019

Content by: Riley Pieper

Present: None

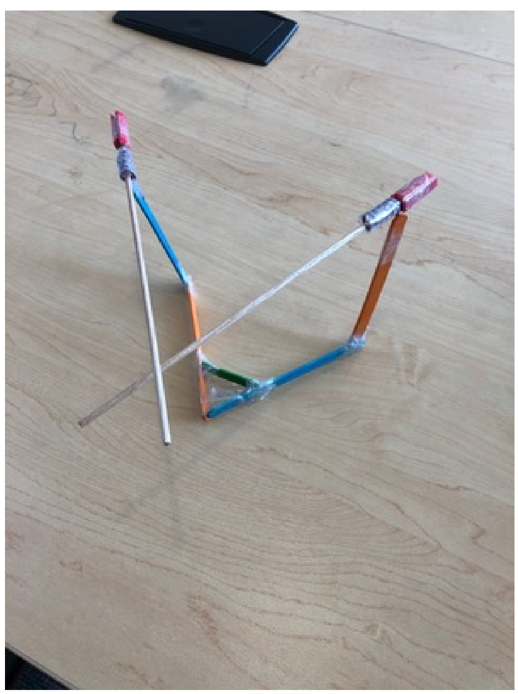
Goals: Design an element to be added to the pizza design that will allow for locating and positioning at the intersection of the rotational axes of the stage.

Content:

- Images of the crude fabrication of this element are depicted below
- Component will be fixed to the pivoting point (same as the cylinder) where it will be free to pivot
  - out of the way of the imaging device
- removable retractable rods will follow lines that intersect at the point of interest
  - the eye of the mouse can be translated to this point

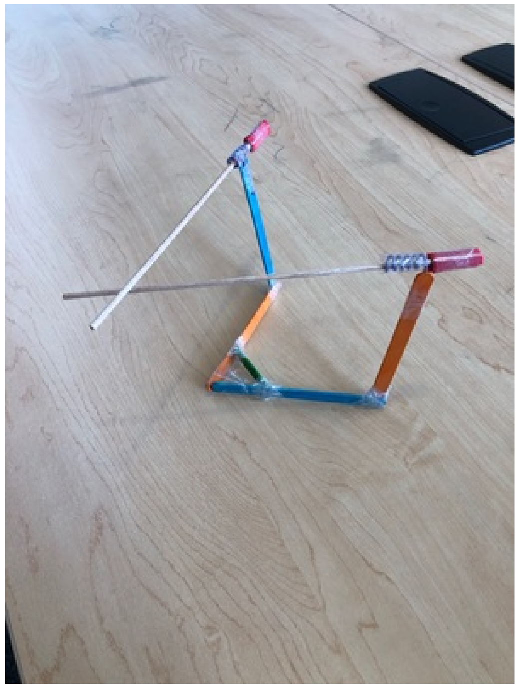
Conclusions/action items: This element will be added to the SolidWorks design of the Pizza design. This design will be fabricated as a proof-of-concept via 3D printing a scale version, and the component depicted below will be included. As the team moves closer to the full fabrication stage, this element may be updated and implemented to the final design as necessary. As one of the key criteria for our design is the positioning of this pupil at the rotational axes, this component will play a key role in the testing of the precision of our device in achieving this criteria.

• RILEY PIEPER • Oct 18, 2019 @01:29 PM CDT



2522B858-D75B-44FB-915A-F73DDBF26AE5.jpg(507 KB) - download

▪ RILEY PIEPER ▪ Oct 18, 2019 @01:29 PM CDT



F60E5242-36CF-409B-837E-08C486D6B846.jpg(534.5 KB) - download

10/22/2019 Updated Pizza Design

▪ RILEY PIEPER ▪ Oct 22, 2019 @07:25 PM CDT

Title: Updated Pizza Design SolidWorks

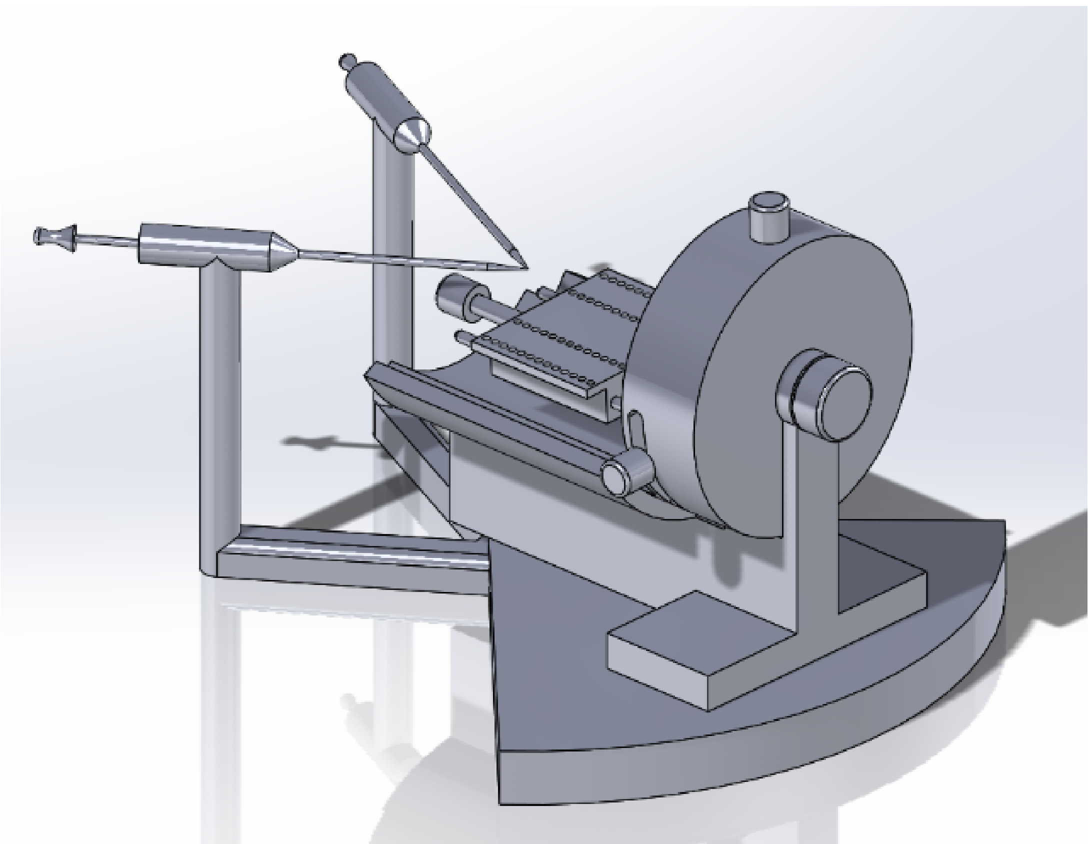
Date: 10/22/2019

Content by: Riley Pieper

Present: None

Goals: Implement the Positioning Rods Component to the pizza design such that the drawing is up to date based on most recent ideas and conversations with client and adviser.

Content:



- V-shaped aligning system sits in front of the stage
- allowed to rotate about the same axis as the pivot of the stage itself
- rotation will allow this element to be moved out of the way of the imaging device
- the rods that actually align (intersecting at the point of interest) move in/out as necessary and are fully removable

Conclusions/action items: As the most up-to-date design, this SolidWorks assembly and the corresponding parts will be taken to Makerspace where the team will consult with Makerspace workers to determine the feasibility of 3D printing a scale version of this design. This scale version could be used as a proof-of-concept. Beyond this step, specific plans for fabrication of the full sized design will be compiled and materials ordered as necessary (the team is still working on fixing the issue of holding the position of the internally translating stage). Finally, this design will be communicated to our adviser and client at the next respective meetings. If issues arise with this design, it will be updated as necessary.

▪ RILEY PIEPER ▪ Oct 22, 2019 @07:27 PM CDT

Aligner.SLDPRT(140.8 KB) - download

▪ RILEY PIEPER ▪ Oct 22, 2019 @07:27 PM CDT

Chopstick.SLDPRT(118.1 KB) - download

▪ RILEY PIEPER ▪ Oct 22, 2019 @07:27 PM CDT

Cradle.SLDPRT(147.5 KB) - download

▪ RILEY PIEPER ▪ Oct 22, 2019 @07:27 PM CDT

Cylinder.SLDPRT(175 KB) - download

▪ RILEY PIEPER ▪ Oct 22, 2019 @07:27 PM CDT

Fin.SLDPRT(78.9 KB) - download

▪ RILEY PIEPER ▪ Oct 22, 2019 @07:27 PM CDT

Pizza.SLDASM(304.4 KB) - download

▪ RILEY PIEPER ▪ Oct 22, 2019 @07:27 PM CDT

Stage.SLDPRT(190.5 KB) - download

▪ RILEY PIEPER ▪ Oct 22, 2019 @07:27 PM CDT

XBar.SLDPRT(143.6 KB) - download

▪ RILEY PIEPER ▪ Oct 22, 2019 @07:27 PM CDT

YBar.SLDPRT(129.6 KB) - download

▪ RILEY PIEPER ▪ Oct 22, 2019 @07:27 PM CDT

ZBar.SLDPRT(57.7 KB) - download

11/22/2019 Diamond Design

▪ RILEY PIEPER ▪ Nov 25, 2019 @04:59 PM CST

Title: Diamond Design (Solidworks Drawings)

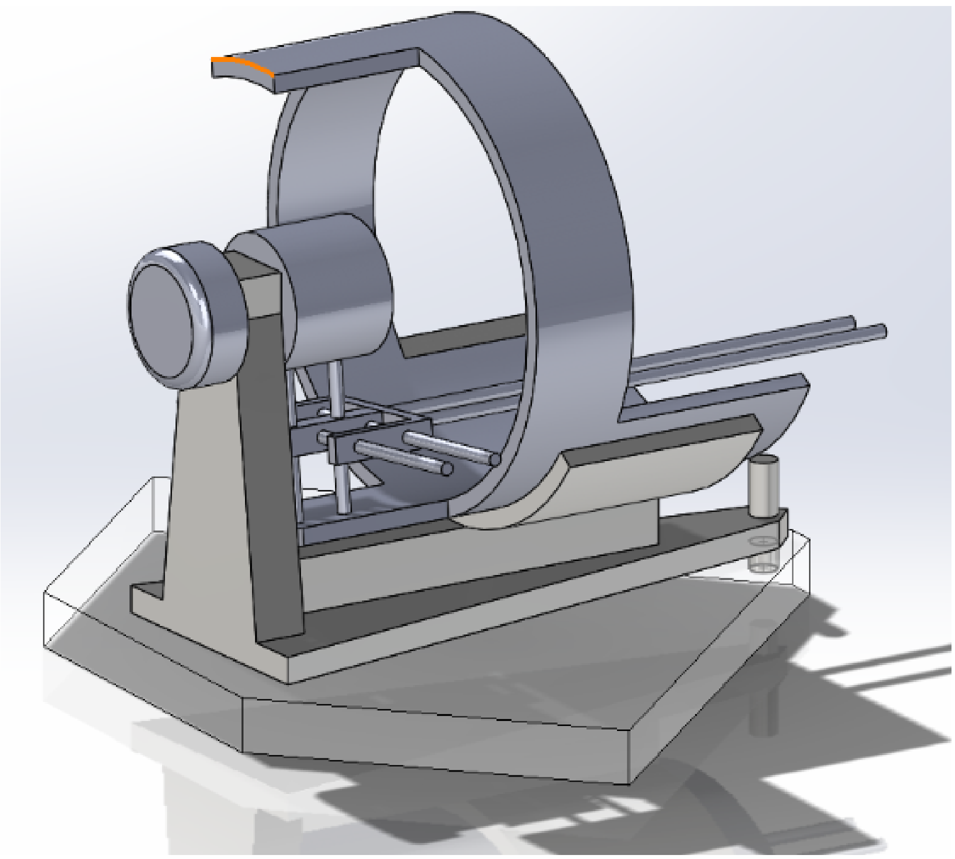
Date: 11/25/2019

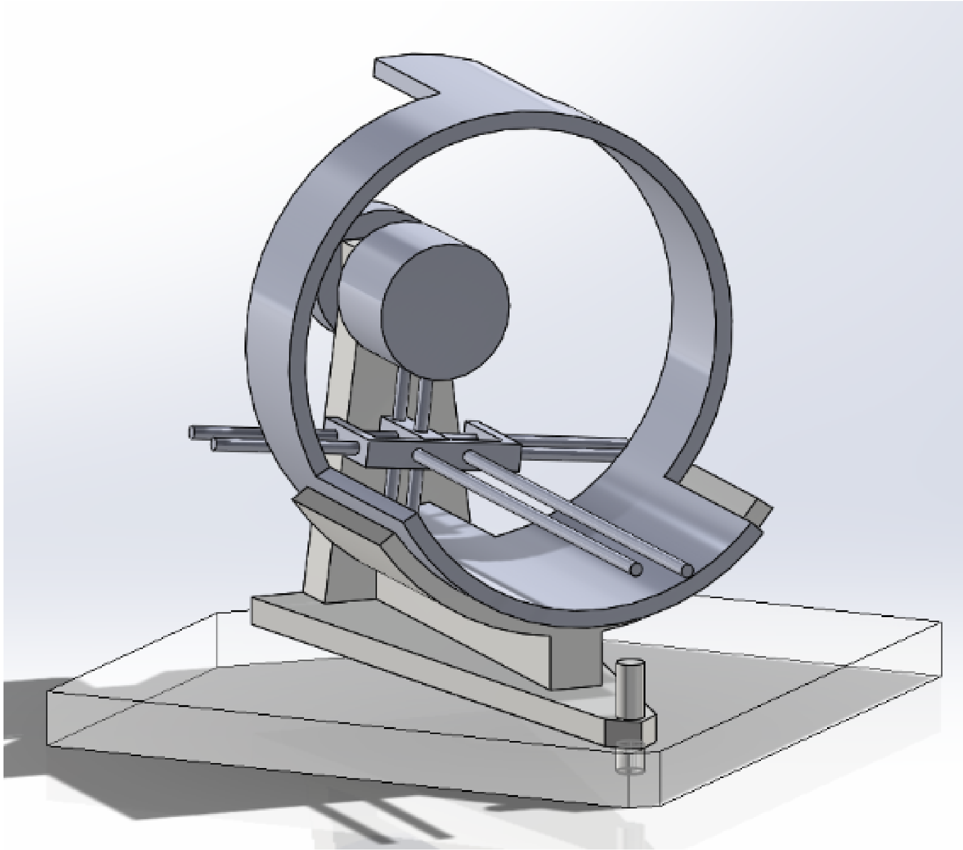
Content by: Riley Pieper

Present: None

Goals: Re-imagine the pizza design according to the materials that we have procured for fabrication and the way in which we have decided to fabricate the elements of the full-scale design.

Content:





Conclusions/action items: This "Diamond" design - so named for the base created in the image of a diamond, is an accurate depiction of the final design as it will be fabricated. At this point, components have been ordered and fabrication has started on some of the elements using scrap parts. Moving forward, fabrication will continue while more parts are acquired. This drawing will be updated as necessary and presented on in our final presentation/report. Still needed on this drawing: aligning component (see Pizza design) and sample-holder carrying stage. In terms of the stage, research must be conducted into commercial rodent stages available to ensure that the stage will be made flexible and usable with stages on the market.

▪ RILEY PIEPER ▪ Nov 25, 2019 @05:00 PM CST

Arms.SLDPRT(154.4 KB) - download

▪ RILEY PIEPER ▪ Nov 25, 2019 @05:00 PM CST

Base.SLDPRT(48.4 KB) - download

▪ RILEY PIEPER ▪ Nov 25, 2019 @05:00 PM CST

Carrier.SLDPRT(135.6 KB) - download

▪ RILEY PIEPER ▪ Nov 25, 2019 @05:00 PM CST

DiamondRRaTS.SLDASM(134.4 KB) - download

▪ RILEY PIEPER ▪ Nov 25, 2019 @05:00 PM CST

Rail.SLDPRT(88.5 KB) - download

▪ RILEY PIEPER ▪ Nov 25, 2019 @05:00 PM CST

Wings.SLDPRT(96.9 KB) - download

12/3/2019 Updated Aligner

▪ RILEY PIEPER ▪ Dec 03, 2019 @09:48 PM CST

Title: Updated Eye Aligner

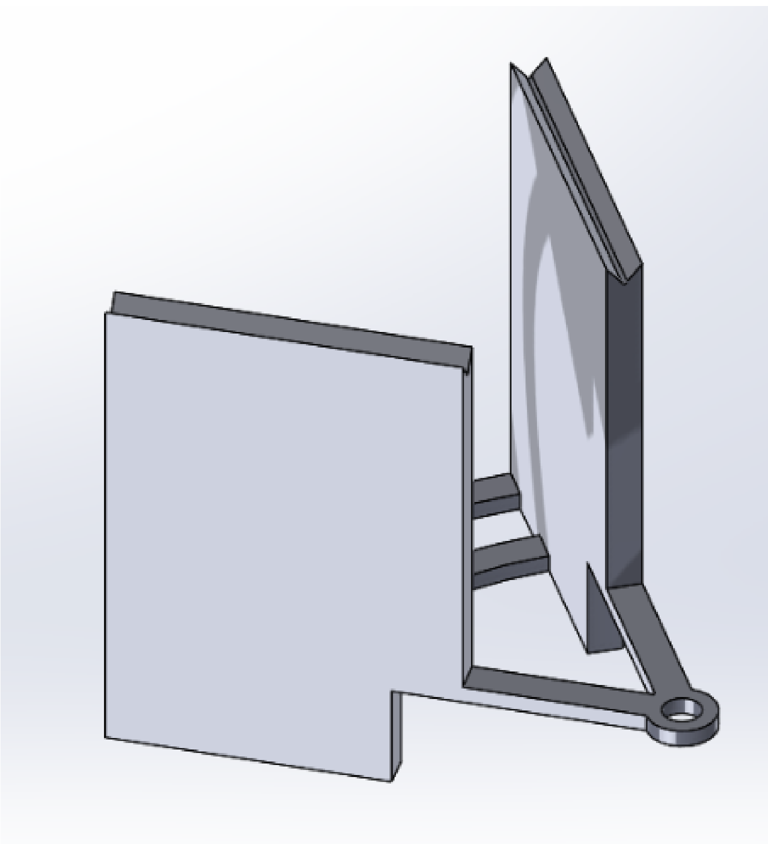
Date: 12/3/2019

Content by: Riley Pieper

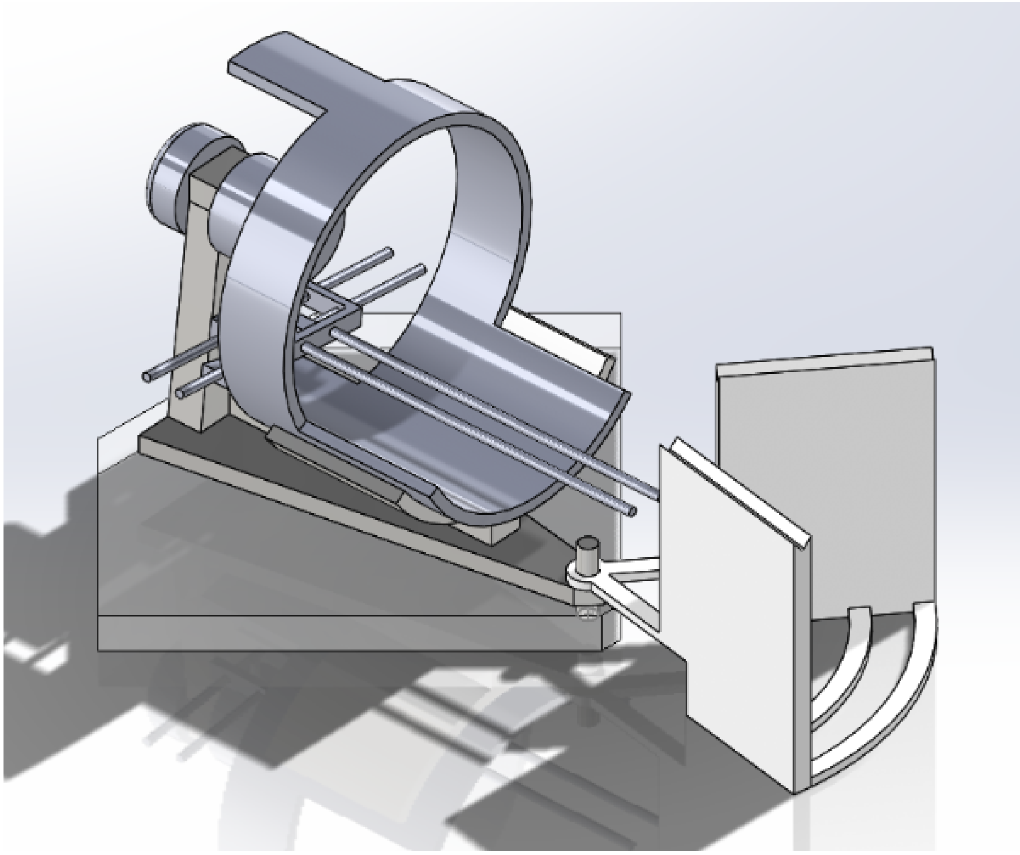
Present: None

Goals: Draw an updated aligner component that could be implemented into the fabricated full-size design. Use this drawing for 3D printing of this part such that it is precisely machined to accurately align.

Content:



This aligner will fit on top of the pivot rotation rod and will be able to be removed following use. The groves on top of the aligner will house the probes provided by adviser Dr. Suminski. Such rods have a telescoping feature that allows them to retract. Thus, the rods can be glued into the part depicted above and be extended to intersect at the intersection of the axes of rotation. This design pinpoints this intersection point by sharing the pivot (yaw) point/rod and being machined to the exact height of the pitch axis of rotation, based on measurements taken of the actual fabricated design. This drawing will be 3D printed and the probes provided added to it.



Above is the full assembly of the current design that is being fabricated

Conclusions/action items: This drawing will be added to the full assembly of the design for the final presentation later this week. Furthermore, it will be printed to full size such that it can be implemented and tested with the full sized prototype stage. The probes provided by Dr. Suminski will be glued to the grooves in the aligner. This part is critical to the planned testing, as the specifications to be tested are most concerned with the accuracy of positioning the eye at the intersection of the rotational axes, the task that this part is central to accomplishing.

12/11/2019 Green Pass

▪ RILEY PIEPER ▪ Dec 11, 2019 @01:10 AM CST

Title: Green Pass Documentation

Date: 12/11/2019

Content by: Riley Pieper

Present: Full Team

Goals: Present the green pass (obtained last semester) used by Riley to fabricate the final prototype in the engineering shop.

Content:

Conclusions/action items: Evidence of shop certification protects Riley and this team from any liability such that proper safe methods were taken while fabricating the final prototype. It is also necessary to know that a green pass is required for the fabrication process, as some procedures were conducted on the mill and lathe.

Research on Biology and Physiology of Rats

▪ KYLE SCHMIDT ▪ Oct 08, 2019 @09:34 PM CDT

Title: Biology and Physiology

Date: Research on 9/28/19, entered on 10/8/19

Content by: Kyle Schmidt

Present: Kyle Schmidt

Goals: To better understand the biology and physiology of rodents

Content:

E. Ades, “Species Specific Information: Rat,” Johns Hopkins University, 11-Mar-2009. [Online]. Available: http://web.jhu.edu/animalcare/procedures/rat.html. [Accessed: 09-Oct-2019].

- Average weight of rats 300 - 500 g (males) or 250 - 300 g (females)
- Average lifespan is around 2.5 - 3.5 years
- When handling rats, use your fingers at the base of the tail. Hold them upside down with thumb and forefinger right the mandibles to reduce the chance of getting bit
- Anesthetics can be administered orally or injected in the anterior thigh muscle, the abdomen or dorsal tail vein
- Inhaled anesthesia is generally safer than injected anesthesia
- Halothane and isoflurane are the safest to use

R. Melina, “Why Do Medical Researchers Use Mice?,” LiveScience, 16-Nov-2010. [Online]. Available: https://www.livescience.com/32860-why-do-medical-researchers-use-mice.html. [Accessed: 09-Oct-2019].

- 95% of all lab animals are mice and rats. Why?
- Convenience: small, easily maintained and adjust to new surroundings easily
- Reproduce quickly and have a short lifespan, so many generations can be observed in a relatively short amount of time
- Inexpensive and docile
- Genetic purity (all have very similar if not identical genetic makeups)
- Genetic, behavioral and biological characteristics are similar to humans
- Symptoms of human conditions can easily be replicated in mice
- Genetic makeup is well understood by researchers, so it's easy to identify changes and causes of human conditions

Conclusions/action items:

In conclusion, rats are good test subjects because of their short lifespan, quick reproduction, genetic purity and biological similarities to humans. Using my newfound knowledge, I will research competing designs and also incorporate my research into designing a stage for the rodents.

Retina Research

▪ KYLE SCHMIDT ▪ Oct 08, 2019 @09:54 PM CDT

Title: Retina Research

Date: 10/1/19 (Published on 10/8/19)

Content by: Kyle Schmidt

Present: Kyle Schmidt

Goals: Understand the basic makeup of the human eye

Content:

"What is the Retina?: Review of the Retina," Retina Specialists Huntington Beach 92647, 2017. [Online]. Available: https://www.vmrinstitute.com/what-is-the-retina/. [Accessed: 09-Oct-2019].

- Retina is lights sensitive tissue lining the whole eye
- Light enters eye at pupil (center of eye) and hits retina, producing images
- Light signals are transmitted to optic nerve and then to the brain
- Retina has 3 layers
  - Photoreceptors - rods and cones which turn light into electrical signals
  - Center of retina is called the macula
- Cornea filters light into the eyeball
  - Cataracts - opacification of the natural lens
- Damage to retina prevents electrical signals from being transmitted to the brain
- Too wet or too dry macula can distort vision and could lead to permanent loss of vision if macula detaches

Conclusions/action items:

In conclusion, the retina houses photoreceptors, which is the key thing being imaged by our client. Research of the retina could lead to improvements in the cure for macular degeneration and cataracts. This research gives me a better understanding of my client's research, and will help me with the design now that I know what is being imaged.

Existing Designs

▪ KYLE SCHMIDT ▪ Dec 09, 2019 @08:36 PM CST

Title: Existing Designs

Date: December 9th (researched on October 10th)

Content by: Kyle Schmidt

Present: Kyle Schmidt

Goals: Research potential ways to achieve all 3 degrees of freedom

Content:

6D Goniometer - https://www.youtube.com/watch?v=6Sv3hPGciVQ

- offers a full 360 degree rotation in two rotational axes
- Offers 90 degrees of rotation in the third rotational axis
- Precision within one micron in one direction and 10 microns in another
- Insanely smooth adjustment
- Computer numerical control

RAS

- See Bioptigen RAS Research

Previous Design Teams Design

- Offers three degrees of rotation
- Magnets allow for variable specimen stages
- Does not keep the eye at the center of rotation, creating a need to re position after each rotation
- Rotation dependent on a gear system which is hard to clean in a lab setting
- Sample holder is not supported by internal support system

Conclusions/action items:

Our design needs to keep the eye precisely aligned at the center of rotation to allow for fluid imaging of the eyes of rodents. From this research, I will incorporate these design elements into our first prototype.

Bioptigen RAS Research

▪ KYLE SCHMIDT ▪ Dec 09, 2019 @08:18 PM CST

Title: Bioptigen RAS Research

Date: 9/18/19

Content by: Kyle Schmidt

Present: Kyle Schmidt

Goals: To research competing designs and see what is currently on the market

Content:

Anon, (2019). [online] Available at: https://www.researchgate.net/figure/Imaging-setup-Overview-of-the-Bioptigen-spectral-domain-ophthalmic-imaging-system_fig3_232234442 [Accessed 8 Oct. 2019].

- Two concentric tubes for holding the rodent
- 2 rotational degrees of freedom (roll from rotating the inner tube, yaw from rotating the tubes side to side)
- Inside the device, there is a degree of translation which allows the inner tube to slide forwards and backwards
- At the base, there is a translation stage which allows for precise alignment in all 3 of the translational degrees of freedom
- This device was very expensive, and does not seem to still be on the market

“Leica Microsystems to Acquire OCT Company Bioptigen,” Leica Microsystems, 01-Jun-2015. [Online]. Available: https://www.leica-microsystems.com/company/news/news-details/article/leica-microsystems-to-acquire-oct-company-bioptigen/. [Accessed: 09-Oct-2019].

- Bioptigen was bought out by Leica Microsystems in 2015

Conclusions/action items:

The RAS device is one competing design in existence, although it is no longer being sold due to the buyout by Leica Microsystems. From here, I will begin working on possible designs and dig into the research our client does.

Bioptigen RAS Research

▪ KYLE SCHMIDT ▪ Oct 08, 2019 @10:09 PM CDT

Title: Bioptigen RAS Research

Date: 9/18/19

Content by: Kyle Schmidt

Present: Kyle Schmidt

Goals: To research competing designs and see what is currently on the market

Content:

Anon, (2019). [online] Available at: https://www.researchgate.net/figure/Imaging-setup-Overview-of-the-Bioptigen-spectral-domain-ophthalmic-imaging-system_fig3_232234442 [Accessed 8 Oct. 2019].

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“Leica Microsystems to Acquire OCT Company Bioptigen,” Leica Microsystems, 01-Jun-2015. [Online]. Available: https://www.leica-microsystems.com/company/news/news-details/article/leica-microsystems-to-acquire-oct-company-bioptigen/. [Accessed: 09-Oct-2019].

- Bioptigen was bought out by Leica Microsystems in 2015

Conclusions/action items:

The RAS device is one competing design in existence, although it is no longer being sold due to the buyout by Leica Microsystems. From here, I will begin working on possible designs and dig into the research our client does.

Gyroscope Design

▪ KYLE SCHMIDT ▪ Oct 09, 2019 @12:42 PM CDT

Title: Gyroscope Design

Date: 9/26/19 (Entered on 10/9/19)

Content by: Kyle Schmidt

Present: Kyle Schmidt

Goals: Create early sketches for potential design ideas

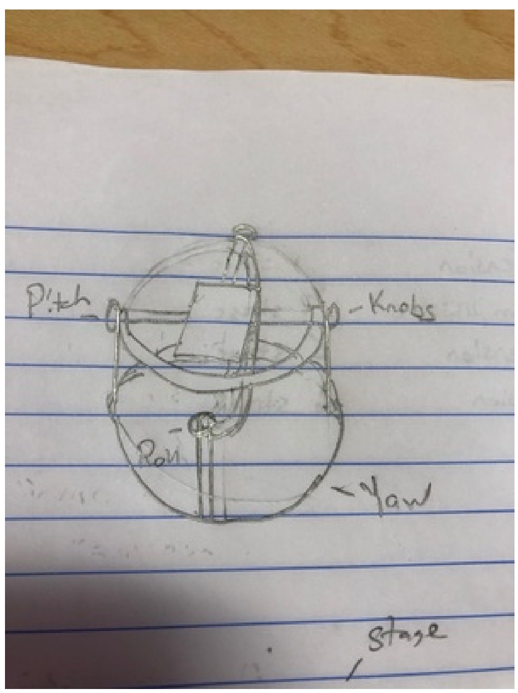
Content:

- Provides rotation in all 3 degrees of rotation
- Pitch and Roll provided by knobs connected to semicircular arches
- Yaw provided by rotation of base
- Would have stage that fits atop the platform and would provide minimal x, y and z translation
- Placed on cart which would roll up to imaging device which would provide the external x, y and z translation

Conclusions/action items:

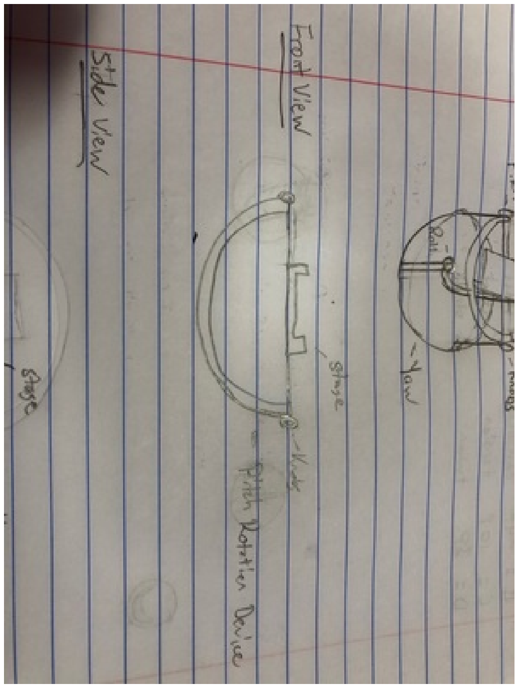
These are early sketches are good ideas for how to incorporate the three rotational degrees of freedom. This design needs to improve upon the stage translation. From here I'll discuss my design idea with the team and hopefully incorporate some aspects of my design in our final decision.

▪ KYLE SCHMIDT ▪ Oct 09, 2019 @12:36 PM CDT



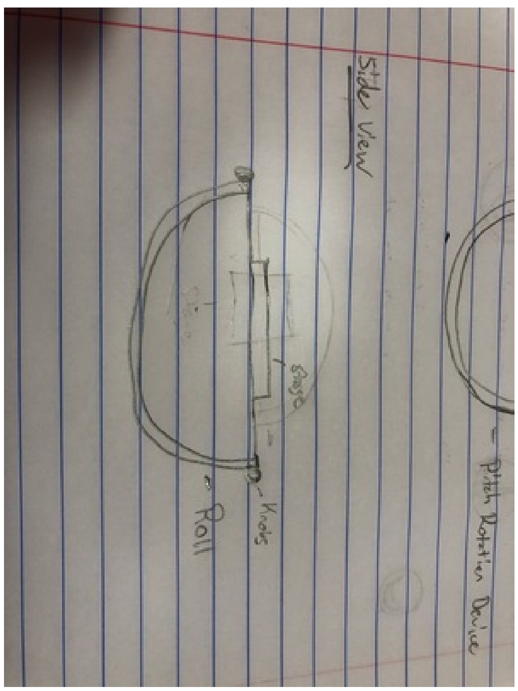
Rough_sketch_of_design.jpg(102.7 KB) - download

▪ KYLE SCHMIDT ▪ Oct 09, 2019 @12:36 PM CDT



Front_view.jpg(118.7 KB) - download

▪ KYLE SCHMIDT ▪ Oct 09, 2019 @12:37 PM CDT



Side_view.jpg(114.2 KB) - download

Materials to Order

▪ KYLE SCHMIDT ▪ Dec 09, 2019 @08:43 PM CST

Title: Materials to Order

Date: November 15, 2019

Content by: Kyle Schmidt

Present: All

Goals: Create a list of materials to send to our client to order

Content:

Base: ABS Plastic

https://www.grainger.com/category/raw-materials/plastics/plastic-sheets-and-film?attrs=Plastic+Material%7CHDPE~~Plastic+Thickness%7C1.000%22~~Plastic+Width%7C12%22&filters=attrs

https://www.grainger.com/category/plumbing/pipe-tubing-and-fittings/tubing/stainless-steel-tubing?attrs=Outside%20Dia.%7C6%22&filters=attrs&ef_id=EAIaIQobChMImqubx4Ht5QIVnf_jBx2X-AQnEAAYASAAEgIgQvD_BwE:G:s&s_kwcid=AL!2966!3!319497170604!b!!g!!&cm_mmc=PPC:+Google+PPC

https://www.speedymetals.com/c-8242-round-tube.aspx

Link to Materials Spreadsheet

https://docs.google.com/spreadsheets/d/1jPnzVL-MoQNg8mGKsvEIoTPAXP9XW0850M5IDBPjT34/edit#gid=0

Conclusions/action items:

Now that we have a clear list of parts to send to our client, he can order them so we can begin fabrication.

Parts to Order

▪ KYLE SCHMIDT ▪ Dec 09, 2019 @08:44 PM CST

Title: Parts to Order

Date: 11/22/19

Content by: Kyle Schmidt

Present: All

Goals: Compile a list of parts to order

Content:

https://www.mcmaster.com/standard-pipe-fittings

4880K132

https://www.mcmaster.com/plastic-pipe-nipples

48925K26

Conclusions/action items:

After compiling a complete list of parts to order, our client can order our materials so we can begin fabrication.

Revised Cylinder

▪ KYLE SCHMIDT ▪ Dec 09, 2019 @09:01 PM CST

Title: Revised Cylinder

Date: 10/6/19

Content by: Kyle Schmidt

Present: Kyle Schmidt

Goals: Come up with a design for a revised cylinder

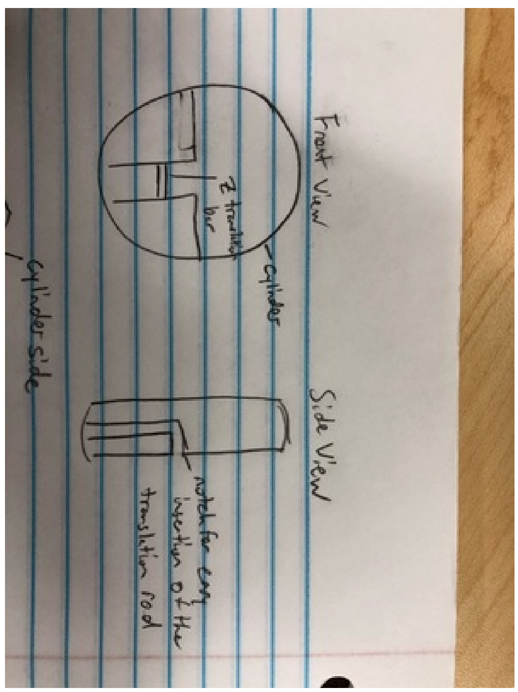
Content:

A cylinder that includes notches in the sides for easy assembly. Allows the z translation rod to slide right in to the cylinder.

Conclusions/action items:

We could incorporate this aspect into our design for easier assembly of our prototype.

▪ KYLE SCHMIDT ▪ Dec 09, 2019 @09:19 PM CST



Revised_Cylinder.jpg(125.3 KB) - download

Supports to eliminate deflection

▪ KYLE SCHMIDT ▪ Dec 09, 2019 @09:05 PM CST

Title: Supports to eliminate deflection

Date: 12/9/19

Content by: Kyle Schmidt

Present: Kyle Schmidt

Goals: Create a prototype to minimize the deflection along our x translation rod

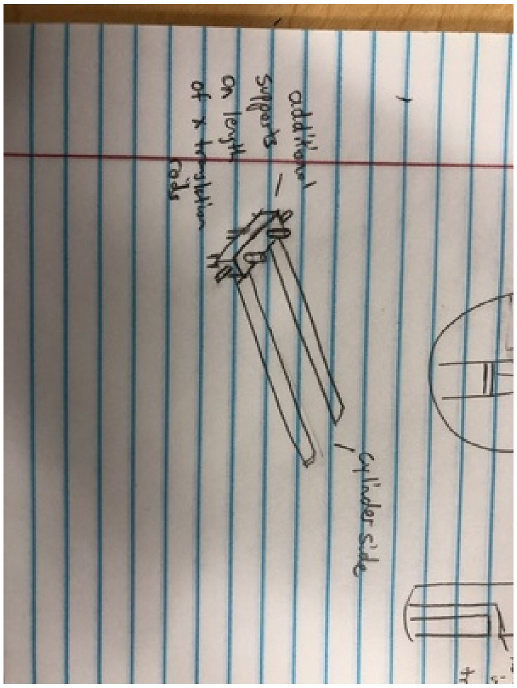
Content:

Design is the same as our existing design, but instead incorporates y and z supports at the end of the translation rods. This applies stability to the length of the translation rod, decreasing deflection. The block connecting the rods to the supports is free to move along the y and z axes, so as not to hinder the location of the eye at the center of rotation.

Conclusions/action items:

In future work, we could incorporate more rods at the end of our x translation rods to support the beam and decrease the deflection along the length of the beam.

▪ KYLE SCHMIDT ▪ Dec 09, 2019 @09:20 PM CST



Supports.jpg(135.2 KB) - download

Future Work

▪ KYLE SCHMIDT ▪ Dec 09, 2019 @09:18 PM CST

Title: Future Work

Date: 12/9/19

Content by: Kyle Schmidt

Present: Kyle Schmidt

Goals: Create a list of future works projects to include in our final report

Content:

Due to time constrictions, we were not able to include everything in our design that we would have liked. I've compiled a list of components to include in the future work section of our Final Report.

- Create variable sample holders
  - Allows for different sized specimens or different species of specimens to be used with our device.
- Incorporate a warming blanket into the stage/sample holder
  - Maintains the rodent's internal body temperature during testing
- Implement a motor
  - Computer aided control would allow for extremely precise rotation/translation of the rodent
- Pair our device up with the cart used in the lab
  - Would prevent the researchers from having to align our device in the field of view of their imaging system
- Test using the actual imaging device
  - Would allow us to get accurate measurements of the deviation of the eye from the center of rotation
- Fabricate out of autoclavable materials
  - Would make cleaning for our client extremely easy, as they would just need to put our prototype in the autoclave.

Conclusions/action items:

I can include these ideas for future work in our final report, and hopefully our client can incorporate these ideas in the future.

9/25 Rat information

• NOLAN THOLE • Sep 25, 2019 @09:11 AM CDT

Title: Rat info

Date: 9/25/19

Content by: Nolan Thole

Present: Nolan Thole

Goals: To understand more about rats and why imaging their eye is important.

Content:

En.wikipedia.org. (2019). *Brown rat*. [online] Available at: https://en.wikipedia.org/wiki/Brown_rat [Accessed 25 Sep. 2019].

- Average brown rat has a head and body length of 28 cm (11 in) and a tail slightly shorter than that.
- Weighs between 140-500 grams (4.9-17.6 oz.).
- They have poor vision, around 20/600
- Perceive color like a red-green colorblind human
- Blue reception has UV receptors, so they can see ultraviolet light that some animals can't
- Gestation period is 21 days
- Litter can go up to 14 but 7 is common
- Female can produce a litter up to 5 times a year

wiseGEEK. (2019). *Why are Rats Used in Animal Testing? (with pictures)*. [online] Available at: https://www.wisegeek.com/why-are-rats-used-in-animal-testing.htm [Accessed 25 Sep. 2019].

Why do we use rats in testing?

- We carefully breed rats and document genetic histories to be used in animal testing.
- We use them because of their frequent reproduction, genetic purity, and similarity to human biology.
- Rats are mammals, so their systems should react to chemicals like a humans system would.
    - We inject them with large doses of new chemicals to make sure they are safe for humans.
- They are tested for genetic defects that could alter experiments.
    - They breed frequently so researchers can see if the tests they performed on one rats affected the next few generations of offspring from that rat.
- Reproduce rapidly with biglitters so researchers can see future generations quickly and if any repercussions from previous tests are present in offspring.

Medicalxpress.com. (2019). *Researchers uncover evidence of restored vision in rats following cell transplant*. [online] Available at: https://medicalxpress.com/news/2018-11-cell-transplant-vision-rats.html [Accessed 25 Sep. 2019].

- We image a rats eye to try to understand it and test various new medicines to see what happens.
- We ultimately want to use information to help human society and improve eyesight.
- One of the main reasons we image rats eyes is for macular degeneration.
- Age-related macular degeneration and retinitis pigmentosa lead to profound vision loss in millions of people worldwide.
- We want to cure these diseases in rats so we can implement the cures in humans to improve medicine and society.
- Researchers from the University of California found that in blind rats the neurons in the visions centers of the brain functioned normally following fetal retina cell transplants.
- Rats with severe retinal degeneration with sheets of fetal cells in the retina generated almost normal visual activity in the brain of the blind rats.
- This study shows promising potential of retinal transplants in humans with retinal degeneration
- That is exactly why we study rats eyes, to improve the eyes of humans

Conclusions/action items:

In conclusion, I learned numerous important things about rats and why imaging them is important. I now need to take what I have just learned and come up with a few design sketches that provides 5 degrees of freedom to image the eye.

9/19 research competing designs

• NOLAN THOLE • Sep 19, 2019 @10:33 AM CDT

Title: Nolan Thole

Date: 0/19/19

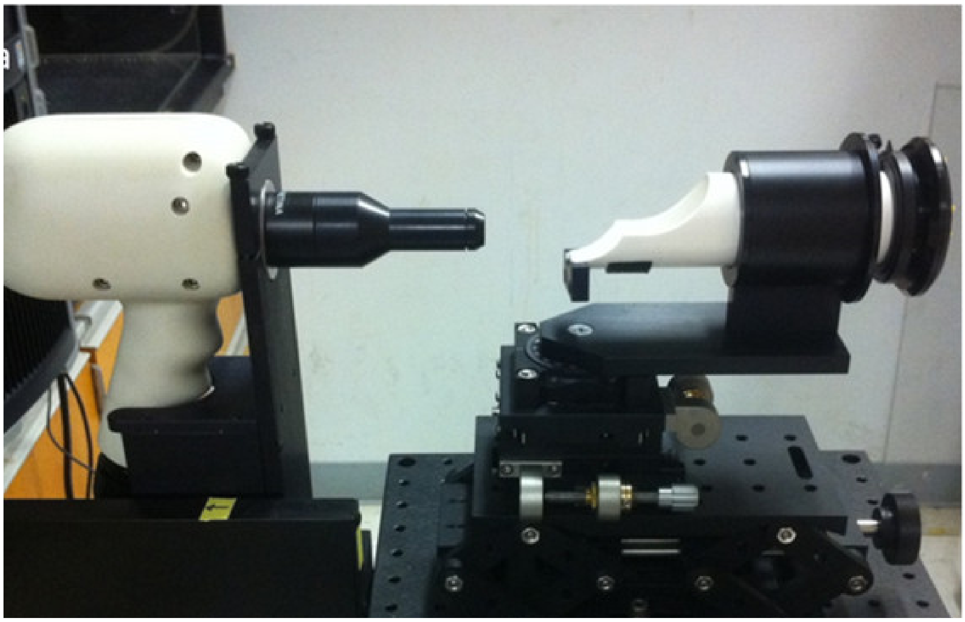
Content by: Nolan Thole

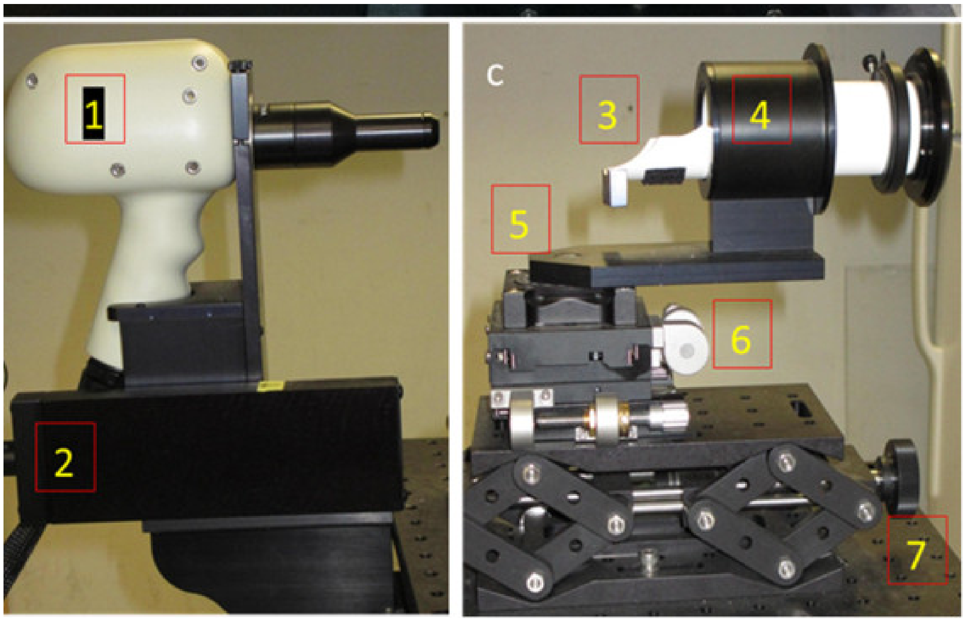
Present: Nolan Thole

Goals: To learn about existing designs and previous solutions to our problem.

Content:

This is a rodent alignment device made by Bioptigen. Bioptigen is a company that manufactures optical coherence tomography systems. However, they were bought out by Leica Microsystems in 2015. Leica Microsystems is a leader in microscopy and imaging systems. I don't think they sell this product though because bioptigen doesn't have a website anymore and I cannot find this device on Leica Microsystem's website. This device provides the necessary degrees of freedom needed to image the eye of the rodent properly. I can't really find any other products on the market for this kind of work, so there is a market out there for us if we succeed in building a good design.

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9/25 device providing 6 degrees of motion

• NOLAN THOLE • Sep 25, 2019 @09:25 AM CDT

Title: Device providing 6 degrees of freedom

Date: 9/25/19

Content by: Nolan Thole

Present: Nolan Thole

Goals: To research devices providing 6 degrees of freedom, not specifically for imaging a rodents eye.

Content:

Aerospace Manufacturing and Design. (2019). *A new approach to six degrees of freedom*. [online] Available at: https://www.aerospacemanufacturinganddesign.com/article/a-new-approach-to--six-degrees-of-freedom/ [Accessed 25 Sep. 2019].

This device pictured above is called the hybrid hexapod which is made by Alio Industries which specializes in nano motion control technologies.

Based on parallel motion. Combines parallel and serial kinematic structures. Uses traditional XY stage, a tripod, and a rotation stage.

Hybrid Hexapod motion features

- Rectangular-prism-shaped working envelopes >10x larger than umbrella-shaped volumes of legacy hexapods
- 360° continuous yaw rotation
- Nanometer accuracy, repeatability
- Monolithic XY Stage provides straightness, flatness
- Linear motor or ball screw- driven tripod links provide linear Z-axis, tip-tilt motion
- Forward, inverse kinematics provides unlimited number of programmable tool center points, precise path trajectories

Conclusions/action items:

This is one idea of how to provide 6 degrees of freedom. I need to research more devices that do this.

9/25 early sketches

• NOLAN THOLE • Sep 25, 2019 @06:10 PM CDT

Title: Design ideas

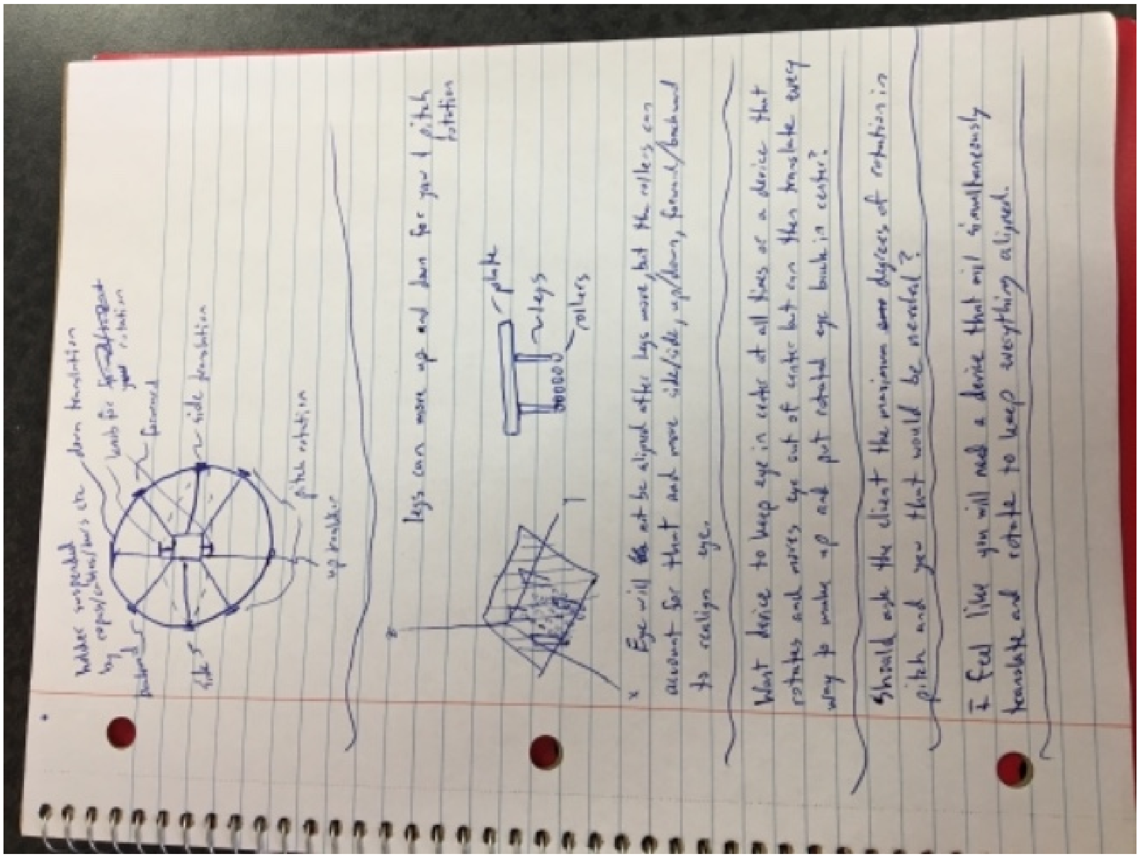
Date: 9/25/19

Content by: Nolan Thole

Present: Nolan Thole

Goals: Come up with design ideas and sketches

Content:



Conclusions/action items:

Come up with more ideas

11/17 magnet research

• NOLAN THOLE • Nov 17, 2019 @11:39 PM CST

Title: Magnet Research

Date: 11/17/19

Content by: Nolan Thole

Present: Nolan Thole

Goals: To research magnets and try to understand how Kevin's magnet idea for the design would work.

Content:

Right now the magnet idea is to attach a bar magnet on one cylinder and a sheet of metal on the other to make the cylinders "stick to each other when rotated". We were worried about the cylinders not staying in position when they are rotated and just falling down when we move them. This is the "friction" component we could utilize to implement the cylinder rotation. This can be compared to a fridge magnet sliding along the fridge. The hope of this design idea is to be able to move the cylinder to the desired position with relative ease and when done rotating it would stay in place because the magnets are attracted and won't want to move on their own. Some concerns for this would be that we would have to find the perfect strength magnet. If the magnet is too attractive it won't move with ease and might not move to the exact position we want and would not be a smooth move but would jump around to different locations. If the magnet is not attractive enough it won't stay in position when we let go of the device. We also want the cylinders to be a smooth rotation and magnets might prevent this from happening.

I just want to do a little research on magnets and understand them more.

YouTube. [Online]. Available: https://www.youtube.com/watch?v=64zkg_PJDjw. [Accessed: 17-Nov-2019].

This is a short video of an experiment where there is an aluminum sheet about .5 meters long at an incline of about 45 degrees. One person put a block on the sheet and another person put a magnet on the sheet. They both released at the same time and the regular block went down the incline fast where the magnet slid down the incline much slower. The block reached the bottom of the aluminum angled sheet in about 1 second and the magnet reached the bottom of the sheet in about 5 seconds. The magnet took longer because it was slightly attracted to the aluminum sheet.

YouTube. [Online]. Available: https://www.youtube.com/watch?v=VEIYXomRdLY. [Accessed: 17-Nov-2019].

This is a video of testing different strengths of materials to a neodymium magnet. In this experiment a man puts a meter long wood board at a 45 degree incline. Attached to this board is a small sheet of aluminum, brass, lead, and then copper. He places a magnet at the top of the ramp and lets it slide to the bottom, testing which material is more strongly attracted to the magnet. The magnet slides down the lead the fastest, then the brass, then more slowly is the aluminum, and the magnet takes the most time to slide down the copper part. From this video I can conclude that aluminum and copper are slightly attracted to magnets and lead and brass are not. Aluminum are copper are not magnetic, but when put near a moving magnet an electric current is generated and the current develops a magnetic field so that magnetic field can be attracted to the magnets magnetic field.

I was just browsing YouTube and magnet tape popped up which I hadn't even thought of for our design. Maybe we could use magnetic tape instead and it might make things a little easier?

Conclusions/action items:

In conclusion, the magnet idea might work for our design. We as a team have to figure out what we are doing and what route we want to go. If we want to use magnets we can either make the top cylinder out of steel or aluminum and put a strip of magnets along the bottom cylinder or we can use pvc pipe for both cylinders and just attach an adhesive magnet to the bottom of the top cylinder. The only reason we thought about including magnets is to have that frictional element of rotation so the cylinders stay in place when they are moved. If we go with this magnet idea we have to decide on the strength of the magnet and material to provide just the right amount of attraction we need.

11/18 material ideas/where to find them

• NOLAN THOLE • Nov 18, 2019 @02:31 PM CST

Title: Material ideas and where to find them

Date: 11/18/19

Content by: Nolan Thole

Present: Nolan Thole

Goals: I want to create a list of materials for the design and look into where we can buy them for our design.

Content:

For the bottom base plate and body under the cylinders we can use some sort of plastic or abs material. Plastic will work because it is slippery enough to allow the yaw rotation of the device with ease but will stay in place once done rotating because of gravity.

For the two cylinders we want pvc pipe and it has to be a relatively big diameter to accommodate for the eye being in the center of the circle to be in the center of rotation. We need 8 inch diameter pipe in a foot long sections.

For the translational component rods we want strong metal rods that won't bend under a force from the weight of the specimen. We can look on Thorolabs for these metal rods as Dr. Rogers has advised.

For the circular part that contains the internal translational elements we can machine it out of a plastic.

For the alignment component we can also use some sort of plastic and then for the rods that go through the aligners to pinpoint the center of rotation we need to pick up some rods from our advisor because he said he had something that would work great for this part.

Looking for PVC pipe:

- Home Depot
    - Couldn't find 8 inch diameter pvc pipe on the Home Depot website
    - What I did find was 6 inch diameter pvc pipe that is 24 inches long
        - cost is $8.97
        - Internet #202564459

          Model # 6006-2

          Store SKU #826829

          Store SO SKU #1000673250
        - https://www.homedepot.com/p/VPC-6-in-x-24-in-PVC-SDR-35-Riser-Pipe-6006-2/202564459
- Lowes
    - Didn't have 8 inch diameter pipe, just had 6 inch and 10 inch
    - The 6 inch only came in 10 foot long sections, which we do not need
    - The bigger diameter pvc pipe you get, the longer the pipe comes, so it might be really hard or they might not even make 8 inch diameter pvc pipe in a foot or two foot long sections
- Ace Hardware
    - only sells up to 6 inch diameter and it is in 10 foot sections
- Amazon
    - sells 8 inch diameter pipe in 10 foot sections
    - right underneath that in Amazon a headline caught my attention which was a 8 inch pvc coupling
        - This got me thinking that if we can't find the desired length of 8 inch pipe, we could always use a coupling instead
            - Then I started researching the length of couplings to see if it would even work
            - The length of an 8 inch coupling is about 8.25 inches
                - https://www.pvcfittingsonline.com/429-080-8-schedule-40-pvc-coupling.html
                    - $20.19 for one coupling
            - We wanted our cylinders to be roughly a foot long so we could possibly get two couplings and put them together somehow, maybe glue them
- Side note one of the other problems we would have is the two cylinders fitting together. If we use the same diameter pvc pipe, the inside diameter and the outside diameter of the pipes wouldn't match so the pipes would not fit inside each other, which is a problem

because this is what we need. My thought was we could get a hard pvc pipe 8 inch diameter for the inside cylinder, and then for the outer one that the inner one sits in we could find a sort of flexible or malleable pvc pipe that would be 8 inches roughly but can stretch so the inner tube would fit nicely in the outer one. I don't even know if they make flexible pipes like this so I will have to do some more research on this.

- Shop@UW
    - Grainger
        - has two options for CPVC 8 inch pipe, but they both come in 10 foot length sections and one is $500 and the other is $1200
            - this is not what we are looking for
        - I was looking at 6 inch pipe just to see and it also comes in 10 foot sections, but then one of the results showed a 6 inch pipe nipple. This got me to thinking that we probably aren't going to be able to find the right length of 8 inch pipe, but we could look for an 8 inch pipe nipple to see how long they come and we could possibly use that
        - Looked at ABS pipe but they only go up to 4 inch diameter
        - Looked for pipe nipples but only could find up to 6 inch nipples, and the longest one was 12 inches and it was $81.58

Conclusions/action items:

In conclusion, I have found that big diameter pipe is really expensive and hard to find. I failed in finding what we need, and it only seems that 8 inch pipe comes in 10 foot sections, which is not what we want. Going forward, I need to do more research in my idea of possibly using couplings or nipples for the cylinder part instead of pipe itself because couplings and nipples would come smaller than 10 foot in length. I also want to look into the idea of flexible pipe more to fit our idea of two concentric cylinders, which I think could work. The flexibility would allow the pvc pipe to sit nicely in the flexible pipe. I will research where to buy magnets and sheet adhesive magnets for the frictional element of our design.

11/19 material research

▪ NOLAN

Title: Material Research

Date: 11/19/19

Content by: Nolan Thole

Present: Nolan Thole

Goals: I hope to find where to buy 8 inch diameter couplings and nipples, if flexible pipe exists and where I can buy it, and find where to buy magnets and sheet magnets.

Content:

Google Search. [Online]. Available: https://www.google.com/search?q=does+flexible+pipe+exist?+pvc&rlz=1C1CHBF_enUS858US858&source=lnms&tbm=isch&sa=X&ved=2ahUKEwjd4LXK7_blAhUDCKwKHdXXDsAQ_AUoAnoECA4QBA&biw=1920&bih=96 [Accessed: 19-Nov-2019].

Flexible pipe does exist, so now I have to see how big of a diameter it can come in.

“Pool Info: Pool Plumbing Pipe: Flex, Rigid, Poly,” *Swimming Pool Plumbing Pipe: Flex, Rigid and Black Poly Pipe*. [Online]. Available: https://www.poolcenter.com/plumbing-pi

- Flexible pvc pipe is used in plumbing of swimming pools.
- It is made from the same thing as rigid pipe, polyvinyl chloride, but flex pipe has plasticizers and surface ribs to allow the pipe to be flexible.

“Advantages of Polyethylene Pipe,” *Advantages of Polyethylene Pipe " Charter Plastics*. [Online]. Available: http://www.charterplastics.com/advantages-of-polyethylene-pipe/. [

- I was browsing Shop@UW Grainger and looking at different pipes and polyethylene pipe came us so I wanted to know what it was.
- I found out is is a flexible pipe that could be what we were looking for.
- HDPE stands for high density polyethylene pipe which is a thermoplastic pipe made from material that can be melted and reformed.
- It is flexible and durable.

Shop@UW

- Grainger
  - Polyethylene pipe only comes in 20 foot long sections and the 8 inch diameter pipe is $490.23 each, so not what we are looking for.
  - Polyethylene tubing only goes up to 3 inch diameter, we need 8
  - Polyurethane tubing only goes up to 3 inch diameter too
  - Ethyl vinyl acetate (EVA) tubing only goes up to 1 inch diameter
  - I have a feeling that all flexible tubing we would need does not go as big as 8 inch diameter
  - Has magnets
    - Found an adhesive magnetic strip 15 feet in length .5 inch width, .06 inch thickness, $6.03 each
    - Found a round base magnet with 4 lb maximum pull, that is 1.21 inches in width and .171 inches in thickness
      - $2.63 each
    - Magnetic adhesive strip 12 lb maximum pull, 10 foot length, 1 inch width, and .06 inch thickness
      - $15.50 each
    - There are also more options for magnets on Grainger
    - Bar magnet alnico 5, .3 lb max pull, 2 inch overall length, 2/5 inch overall width
      - could possibly make a groove with the mill in the middle piece of design where the cylinders sit and place the bar magnet in the groove
      - then we could use the magnetic adhesive to stick the flexible magnet to the bottom of the top cylinder

Conclusions/action items:

In conclusion, flexible pipe exists and is a good idea, but the size we need for our project doesn't exist. We need 8 inch diameter flexible pipe and companies don't make that size. There are ma that we can use for our design, and we can order them on Grainger. I need to next look into fabrication methods and testing method ideas.

11/20 Pipe fitting research

• NOLAN THOLE • Nov 20, 2019 @02:08 PM CST

Title: Pipe Fitting Research

Date: 11/20/19

Content by: Nolan Thole

Present: Nolan Thole

Goals: Find 8 inch pipe and think of how to fabricate and test.

Content:

I was browsing McMaster Carr and I think I found what we are looking for.

McMaster Carr "Carr," *McMaster*. [Online]. Available: https://www.mcmaster.com/plastic-pipe-nipples. [Accessed: 20-Nov-2019].

- Has pipe size 8 inch pvc pipe nipples
- Standard-Wall Plastic Pipe for Water
  - https://www.mcmaster.com/plastic-pipe-nipples
  - The cheapest 8 inch pipe fitting is a rigid pipe unthreaded
  - Pipe size is 8 and it is schedule 40
  - Outer diameter of 8 and 5/8 inches and inner diameter of 7.981 inches
  - Wall thickness .322 inches
  - White pipe with maximum pressure of 160 psi at 72 degrees F
    - The max pressure doesn't matter at all to us because we are not pushing fluid through the pipe for our design, we just need the shape and diameter
  - Price is $82.59 each for a 5 foot section and $142.40 each for a 10 foot section, but we would only need the cheaper 5 foot long pipe
  - There is also a pipe cement for pipe size greater than 6 for $6.38 for an 8 ounce can
    - We could maybe use this to adhere the pipe to the bottom base sticking up, but it might not work because pipe cement is usually just for adhering pipe together.
  - This rigid pipe is the cheapest and shortest 8 inch diameter I have found so far
  - If we can't find anything better on Shop@UW we will have to prove we can't find it on there and then we could order it from an outside vendor like McMaster Carr because they are not listed as one of the vendors on Shop@UW
- Also has 8 inch flexible tubing we could put the rigid tube in for the two cylinders in the design
  - https://www.mcmaster.com/standard-plastic-hollow-tubing
  - Slippery UHMW Polyethylene Tubes
    - Has a low friction surface that resists sticking and binding
    - White
    - Hardness of 65D-67D (medium)
    - Wall thickness of 3/8 inch
    - Outer diameter of 8 5/8 inches
    - Inner diameter of 7 7/8 inches
    - Comes in lengths of 1, 2, 3, 4, or 5, feet
    - $53.96 per foot
    - I think this product would be perfect for what we are trying to do
  - Chemical-Resistant PVC Tubes
    - Made of PVC Type 1, which is easy to thermoform
    - Gray
    - Wall thickness of 1 7/16 inches
    - Outer diameter of 8 5/8 inches
    - Inner diameter of 5 3/4 inches
      - Not what we are looking for so this material is out of the question
    - Comes in lengths of 1, 2, 3, 4, or 5, feet
    - $220.70 per foot
      - Too expensive for us

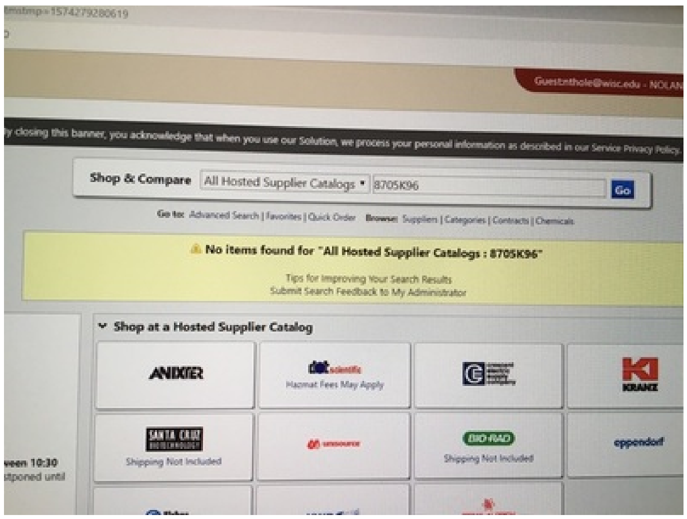
The 8 inch pvc pipe has to fit into the 8 inch flexible pipe so the outer and inner diameters must be roughly the same. The outer diameter of the hard pipe is 8 5/8 inches, which needs to match the inner diameter of the flexible pipe, which is 7 7/8 inches. These diameters are off by 6/8 or 3/4 inch. The hard pipe is 3/4 of an inch too big to fit inside the flexible. However, that is exactly why I thought we could use a flexible material instead of two hard pvc cylinders that won't work. The flexible pipe could bend a little to allow for the hard pipe to rest inside. Also, we are cutting the pipe more than in in half, probably into a third roughly so this will also help to allow for the hard pipe to rest inside because the pipes will be more open. I looked on the website for a bigger inner diameter of the flexible pipe, but the jump is up to 9 inch inner diameter and costs $444.27 per foot, which is way too expensive for our project.

The two images below are proof of my not being able to find the part number on the Shop@UW site, so we have to order them from McMaster Carr. I typed in the part number I needed and it didn't find any results.

Conclusions/action items:

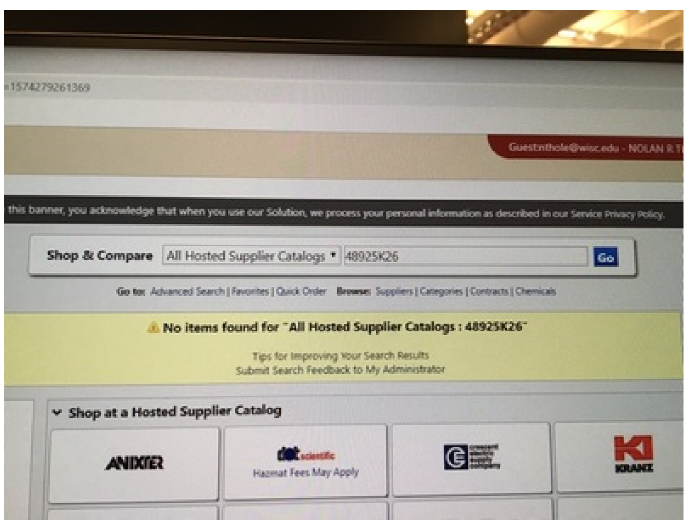
This could definitely work for the cylinder pieces of our design, and the total price for both pipes would be $136.55, which is a bit pricey but we have a budget of $350. I think the next steps are meeting with the team and discussing these options.

▪ NOLAN THOLE ▪ Nov 20, 2019 @02:06 PM CST



BC9923B3-3708-487B-9F74-F2EF86B0265A.jpg(79.3 KB) - download

▪ NOLAN THOLE ▪ Nov 20, 2019 @02:06 PM CST



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12/10 Future work

• NOLAN THOLE • Dec 10, 2019 @05:36 PM CST

Title: Future Work

Date: 12/10/19

Content by: Nolan Thole

Present: None

Goals: List out some things we can do in the future for this project if we were to continue it.

Content:

- Find materials for the two cylinder parts so that they are perfectly concentric with each other.
    - The coupling we used had a tapered edge so when we put the pvc pipe inside it did not rest flat and was at an angle because of the taper and put pressure on the bottom rods.
- Shorten the 10 inch rods we used because those were a little too long
    - We did not need that much translation in that direction and it just added more weight with a longer arm to increase the moment and made the device deflect more.
- Figure out a way to minimize the deflection of the translational rods because this effected the eye not being perfectly centered when rotated in roll in the y axis.
    - Possibly add support to the rods, but would be hard because they need to move around and support might inhibit this
- The translational rods sometimes stuck and bound up and were hard to slide along
    - Figuring out a way to incorporate smooth, fluid motion with relative ease would greatly impact this device
- In the future a mechanical motor could be attached and then coded to rotate the device an exact angle specified by the user
    - This wasn't important currently because our client wanted to move the device by hand and didn't need that much precision because of the computer based feedback, but this might be a nice element to have for other users
- Look into a putty of some sort or goopy substance to put in the hole in the back of the device where everything is connected and rotates about so give it an extra friction element
    - This would allow the pin to rotate, but once rotated it would stay in place because of the sticky material placed in
- Put measurements on the cylinder to see how far you have rotated the device
    - Could put angle marks on the edge of the cylinder
- We didn't focus on creating the different sized sample holders but we would need to do this if he wanted to actually use this device
    - We would make a sample holder for a rat, ground squirrel, mouse, and individual eye
- We also need a warming blanket because the rodents can't regulate their body temperatures well when anesthetized
    - This would drape over the rodent on the sample holder and has to be secured in place so it doesn't fall off when rotated
- The sample holder could also incorporate a bite bar to keep the rodent more situated and still when imaged
- We also need to test this device with a live rat and test the eye rotation with the imaging device

Conclusions/action items:

In conclusion, we made substantial progress with this problem and project this semester. We accomplished the problem of keeping the eye in the center of rotation, but further work would be needed in order to use this device to image rodents in our client's lab.

2019/09/15-Lab Conditions

▪ Kurt Vanderheyden ▪ Oct 09, 2019 @12:13 PM CDT

Title: Lab Conditions

Date: September 15, 2019

Content by: Kurt V

Present: Kurt V

Goals: To learn about the environment that the rats and the translational and rotational stage will be exposed to in the lab.

Content:

- there are over 7 billion lab tests that happen in the US each year and most occur in similar environments
  - having the right kind of environment can provide that the results are reliable and consistent with the real world
- two of the main features that are important in the lab are temperature and humidity.
  - regulating this prevents sample contamination and provides good results
  - optimal temperatures are between 20 and 25 degrees Celsius
  - the optimal humidity range is between 30 to 50 percent
  - these ranges are provided by the FDA guidelines for labs
- importance of temperature and humidity
  - improper control of these can lead to contamination by the growth of microbes and also bacteria that can ruin the credibility of the testing
- ways to keep temperature and humidity constant
  - keeping control and maintenance of the tools that are used in setting these
  - knowing how to monitor the temperature and humidity at any second to know if something has changed

SensoScientific. (2019). *How to Maintain Optimal Laboratory Temperature and Humidity*. [online] Available at: https://www.sensoscientific.com/blog-maintain-laboratory-temperature-humidity/ [Accessed 25 Sep. 2019].

Conclusions/action items:

The optimal temperature and humidity range for a lab environment are 20-25 degrees Celsius and 30 to 50 percent respectively. If either gets out of range, this can lead to contamination of results by growth of bacteria and other microbes. In order to get good results, materials that can last a long time in this environment would be the right choice to allow for a longer life in service.

2019/09/20-Friction in Rotation

▪ Kurt Vanderheyden ▪ Dec 03, 2019 @01:34 PM CST

Title: Friction in Rotation

Date: October 9th, 2019

Content by: Kurt V

Present: Kurt V

Goals: To learn about how friction can be used to accomplish the rotational aspect of the stage.

Content:

- position stages are used in many applications like the one our client is looking for
- a friction drive system requires no gear reduction which prevents the need of backlash
- the stage can stay very stable due to a large static frictional force
- the friction doesn't require lubricant which makes it better use for clean environments
- friction allows for high precision and movement
- some negatives of friction is that it requires strong wear resistant materials
- friction is good to use for small load and high precision limited by Coulomb friction force
- in the past 1 or 2 DOF stages have been developed

Chang, W. (1999). A High Precision Three Degrees of Freedom Friction Drive Stage. [online] pp.8-10. Available at: https://dspace.mit.edu/bitstream/handle/1721.1/80626/45994265-MIT.pdf?sequence=2 [Accessed 1 Oct. 2019].

Conclusions/action items:

Friction would be the right choice to accomplish the rotational aspect of the stage being that the benefits outweigh the negatives immensely. Since there has been 2 DOF friction stages developed before, it would be beneficial for us to look at those designs for ideas because we are looking to accomplish the 2 degrees of freedom of pitch and yaw for rotation.

2019/10/9-Test Subjects

▪ Kurt Vanderheyden ▪ Dec 03, 2019 @01:29 PM CST

Title: Test Subjects

Date: 10/9/2019

Content by: Kurt

Present: Kurt

Goals: To learn information about the possible test subjects that will be used on the device and information about them.

Content:

- Rats-
  - Size= typically 5 inches or longer
    - most are around 8 inches
    - largest species is the bosavi woolly rat (32.2 inches and 3 lbs)
  - habitat= found all over the world
    - house rats typically like warmer climates, while brown was live in temperature climates
    - typically anywhere humans live
  - A. Bradford, "Facts About Rats," *LiveScience*, 30-Sep-2015. [Online]. Available: https://www.livescience.com/52342-rats.html. [Accessed: 09-Oct-2019].
- Mice-
  - Size= the average size is 5-8 inches with a 2-4 inch tail
    - the average weight range is .4- .8 ounces
  - Habitat= found all over the world like other rodents
    - most live in close proximity to humans because they rely on our food and shelter
    - have nests in dark and quiet spaces and remain within about 10 feet of their nests at all times
  - "Facts About Mice," *Havahart*. [Online]. Available: http://www.havahart.com/mouse-facts. [Accessed: 09-Oct-2019].
- Squirrels-
  - Size=there are many kinds of squirrels so they range greatly in size
    - the most popular squirrel in north America is the grey squirrel , 15-20 inches and a tail adding 6 to 9.5 inches
    - typically weigh about 1 to 1.5 pounds
  - Habitat= found all over he world besides Australia and Antartica
    - typically live in wooded areas and like to live inside of trees
    - some hibernate in burrows during the winter time to stay warm
  - A. Bradford, "Squirrels: Diet, Habits & Other Facts," *LiveScience*, 27-Jun-2014. [Online]. Available: https://www.livescience.com/28182-squirrels.html. [Accessed: 09-Oct-2019].

Conclusions/action items: The common animals that are used by our client are mainly mice and rats. Knowing the size and habitat of these animals will help us to design a stage that will functionally hold the rodent while keeping the rodent in a comfortable environment. The stage should be at least 10 inches to allow for even the larger of rats that could be used to still fit on the stage.

2019/09/30-Hexapod

▪ Kurt Vanderheyden ▪ Oct 09, 2019 @11:42 AM CDT

Title: Hexapod

Date: september 30th, 2019

Content by: Kurt V

Present: Kurt V

Goals: To learn about the hexapod device that our client told us about to learn what can be incorporated into our design.

Content:

- As seen in the picture below, the hexapod allows for translation and rotation about the x, y, and z axes.
    - This means it accomplishes all 6 of the DOF possible; X,Y,Z, pitch, roll, and yaw
- this device works by using an actuator system and parallel kinematics positioning systems to allow for a variety of setups on the stage
    - the user of the device sets the pivot point for where they want, but then a computer system is required for moving.
- there are many different sizes, ranging from being capable of holding 2kg-2000kg while still being able to self lock
- a software package is required to operate this device
- the hexapod compared to other kinematic stages has lower inertia, improved dynamics, higher stiffness, and also a smaller package size
- due to the precision and materials used for the hexapod, the cost is very expensive and out of our price range

Pi-usa.us. (2019). *Hexapod Positioner | Six DOF | Stewart Platforms*. [online] Available at: https://www.pi-usa.us/en/products/6-axis-hexapods-parallel-positioners/ [Accessed 30 Sep. 2019].

Conclusions/action items:

The hexapod device is too complex and requires more than what is necessary for our client for us to go with a similar design. There is a couple things from the device that can be useful for our design like accomplishing rotation and translation one one movement instead of having to operate multiple different switches and knobs to achieve the desired positioning.

▪ Kurt Vanderheyden ▪ Oct 09, 2019 @11:35 AM CDT

image.png(35.4 KB) - download

2019/09/30-Linear Stages

▪ Kurt Vanderheyden ▪ Oct 09, 2019 @12:07 PM CDT

Title: Linear Stages

Date: September 30, 2019

Content by: Kurt V

Present: Kurt V

Goals: To learn about previous devices and designs that can be helpful in achieving the translation requirements of the client.

Content:

- a linear stage by dover motion allows for translation and there is a lot of different wats that this is done
- they have linear motor stages, xy stages, microscope stages, screw driven stages, air bearing stages, and gantry stages
- they are usually an automated positioning system that us available in either a single axis translation, or two axes of translation at once
- no matter what axis is being translated, the 6 degrees (x, y, z, roll, pitch, and yaw) of freedom must remained constrained so that it travels in a straight line
- the guides and rails that the stage uses can be ball and crossed roller bearings, recirculating bearings, wheels, air bearings, belt and pull, friction screws, or even just linear motors
- the device requires a linear feedback device to know how precise the movement is and where the exact location of the stage is

Conclusions/action items:

Based on what was found on the linear stage, again a lot of these kind of products require technology and expensive moving parts to function. A beneficial thing that can be applied to our design is that we can use wheels or bearings to slide the stage to the right location. Since our client doesn't really require too much precision with the translation, the feedback device that is required for many of these devices may not be required for us, even though the client already has a feedback system that can be incorporated.

▪ Kurt Vanderheyden ▪ Oct 09, 2019 @11:53 AM CDT

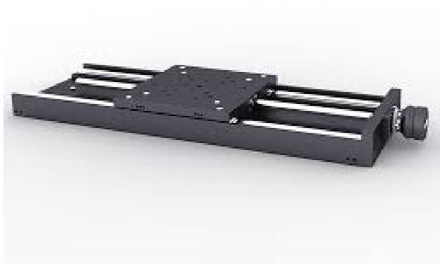


image.png(20.9 KB) - download

2019/10/30-THOR LABS XY Translation Stages with Rotating Platform

▪ Kurt Vanderheyden ▪ Dec 04, 2019 @03:59 PM CST

Title: THOR LABS XY Translation Stages with Rotating Platform

Date: October 30, 2019

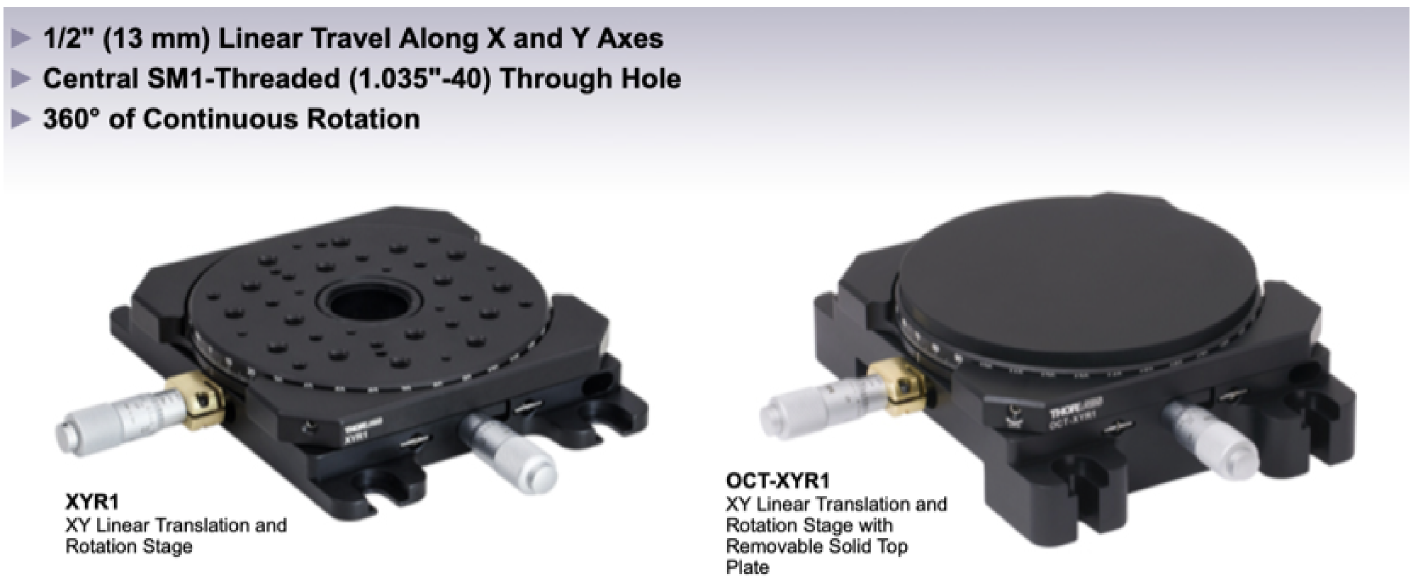
Content by: Kurt V

Present: Kurt V

Goals: To look at existing designs and products out there to see how they can be incorporated into our design.

Content:

- **this** design consists of XY stage and a rotating platform
- the stage can travel 13mm in either the x and y direction and also has 360 degrees of yaw rotation
    - the precision is 10 micrometers precision
- there is a scale on the edge of the stage's rotating platform and can be locked using a set screw
    - the translational movements are still available when locked
- there is an array of different morning elements on the platform to allow for a variety of mounting of samples and components
- for applications that do not require require rotation, there are non rotating mounting surface options on thorlabs



XY Translation Stages with Rotating Platform. [Online]. Available: https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=3693. [Accessed: 30-Oct-2019].

Conclusions/action items:

This current product from thorlabs provides some insight for elements we can incorporate into our design, but since it only satisfies 3 of the 5 DOF required, it alone is not enough for our client. Some important things from this is the setscrew idea to lock certain elements in place whether it be rotation or translation. It also is nice that there is the scale along the outside of the rotation element but our client said that is not necessary.

2019/10/20-frictional materials

▪ Kurt Vanderheyden ▪ Dec 04, 2019 @04:16 PM CST

Title: Friction Materials

Date: October 20, 2019

Content by: Kurt V

Present: Kurt V

Goals: To learn more information about friction based materials and how/what we can use for our design.

Content:

- friction materials are used in systems that require specific contact between two or more parts
  - typical uses= brake and clutch systems, transmissions, and household items
  - industries= aircraft and aerospace, automotive, railroad, and heave machine manufacturing
- some examples are paper, elastomeric, graphitics, sintered metals, ceramics, metal alloys
  - the selection of material is based on the application that the person is interested in based on temperatures involved and required performance
- the more a friction material is used, the less effective or smaller it will become
  - each material has a predictable lifespan that suppliers and manufacturers should be able to estimate.

"About Friction Materials," *About Friction Materials*. [Online]. Available: https://www.thomasnet.com/about/friction-materials-31421803.html. [Accessed: 20-Oct-2019].

Conclusions/action items:

There are lots of materials available for our friction application when it comes to the rotation element of roll. We are looking to incorporate friction to hold the possible pvc pipe or other material in place after it has been rotated. In deciding what material we want to use, it will be important to look at the exact application suggested for the material and also the life in service so that we meet our clients needs. Other ideas that have bounced around for locking the pipes in place are set screws are possibly magnets. I will look into those later and see how those elements compare to friction.

2019/11/15-Bearings

▪ Kurt Vanderheyden ▪ Dec 04, 2019 @03:58 PM CST

Title: How Bearings Work

Date: November 15, 2019

Content by: Kurt V

Present: Kurt V

Goals: To understand how bearings work and see if there is a way they can be incorporated into our current design or future designs

Content:

- bearings= mechanical assembles with rolling elements and inner and outer races that are used for rotating
    - many kind: ball and roller bearings, linear bearings, and mounted versions the use either rolling elementals bearings or plain bearings
- ball bearings= have spherical rolling elements and are used for lower load applications
    - means of supporting rotating shads and minimizing friction between shafts and stationary members
    - high speeds or high precision applications with large range of standardized forms
- roller bearings= use cylindrical rolling elements for heavier load carrying requirements
    - means of supporting rotating shads and minimizing friction between shafts and stationary members
    - can handle higher loads than ball bearings, but less degree of standardization
- linear bearings= used for linear movements along shafts and can have rotational capabilities
    - consist of ball or roller elements in housing and used for linear movement along shafts
    - lower friction, higher price, more complex, and higher accuracies than bushings
- mounted bearings= assemblies when bearings are preassembled in mountings that turn
    - too complex for what we need

"Types of Bearing Classifications and How They Work," *Types of Bearing Classifications and How They Work*. [Online]. Available: https://www.thomasnet.com/articles/machinery-tools-supplies/bearing-types/. [Accessed: 15-Nov-2019].

Conclusions/action items: Based on what I saw on this website and what was learned, bearings may be something that could be beneficial with our design. The most beneficial would be using ball bearings in the yaw rotation element. This is because it is a low load that would be applied to the bearing, and it would minimize the friction between the post and base allowing for smooth and accurate movement for our client.

2019/11/3-magnets

▪ Kurt Vanderheyden ▪ Dec 04, 2019 @05:27 PM CST

Title: Magnets

Date: 11/13/2019

Content by: Kurt V

Present: Kurt V

Goals: To learn more information about magnets and determine whether or not it would make sense to incorporate them into the design.

Content:

- magnet=something that has a magnetic field and attracts ferrous objects
    - ferrous objects= iron, steel, nickel, and cobalt
    - artificially made in various shapes and sizes, with a long rectangular bar of uniform cross section being the most popular shape
    - magnets have two poles (north and south), with like poles repelling each other and unlike poles attracting

Conclusions/action items:

A magnet could be used to hold rotational elements in place. We could use a common rectangular bar and put it into something like a pvc pipe, and then have a ferrous inner pipe made of iron or steel on the inside. The attraction between the magnet and the ferrous material would hold the inner tube in place following rotation, allowing for the client to move the rodent to the desired location. A possible negative of this would be the price of ferrous materials is general more than things like aluminum or pvc, so it may be out of our budget to try and incorporate the magnet idea into our design.

2019-09-24- Chalice initial Design

▪ Kurt Vanderheyden ▪ Oct 09, 2019 @11:32 AM CDT

Title: Initial Design Chalice

Date: 09/24/2019

Content by: Kurt V

Present: Kurt V

Goals: To draw out and explain an initial design idea.

Content:

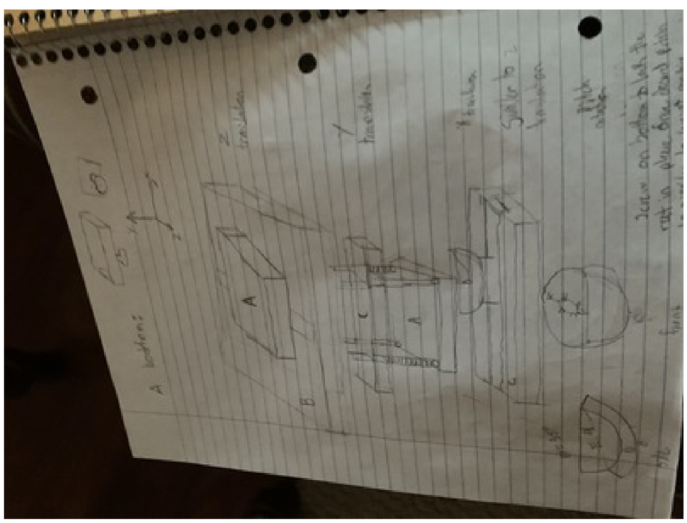
The way this design works is by sliding in the x and z directions on rails to achieve the translation aspect desired. For the y translation, there are 4 poles that the stage can slide up and down on. The stage locks in the y direction by having two poles diagonal of each other threaded so a nut can go beneath the stage and lock the stage at the desired height.

For the rotation, the top of the stage, the chalice part, consists of two hemispheres inside of each other. This allows for the rotation and locking by the use of friction. The outer bowl has part of the front cut off to allow for easy movement of the inner sphere where the actual stage resides. As shown in picture 2, there is an offset of 30 degrees in the pitch direction because the client requested that the stage can be rotated +/- 30 degrees from the origin in both the pitch and the yah axes.

Conclusions/action items:

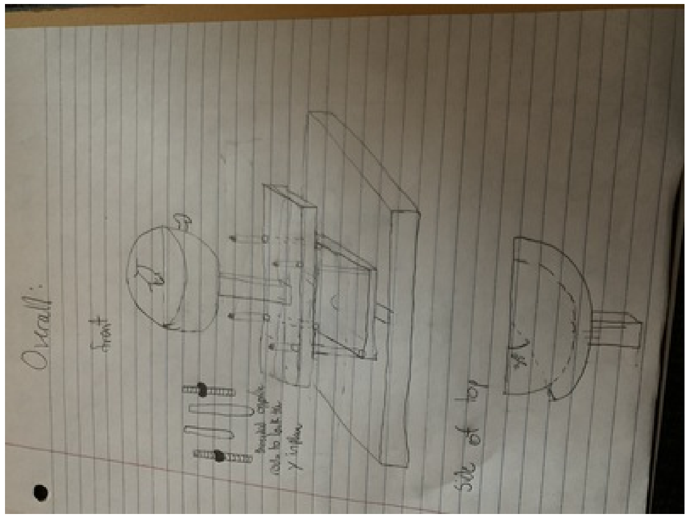
This device does a nice job of incorporating the degree of freedom requirements that the client requires, but it lacks in the area of keeping the eye at the center of the rotation, the size of the device, and also the complexity with a lot of different moving parts.

▪ Kurt Vanderheyden ▪ Oct 09, 2019 @11:20 AM CDT



IMG_0519.jpeg(2.6 MB) - download

▪ Kurt Vanderheyden ▪ Oct 09, 2019 @11:20 AM CDT



IMG_0518.jpeg(2.7 MB) - download

100719 Effects of lasers on eyes

▪ KEVIN TAN ▪ Dec 11, 2019 @12:35 AM CST

Title: Effects of lasers on eyes

Date: 10/7/19 revised 12/10/19

Content by: Kevin Tan

Present: Kevin Tan

Goals: Evaluate lasers as a viable method for eye alignment

Content:
Motivation: The design will have a point where the two axes of rotation intersect. In order to image the specimen's eye the eye must be put exactly at that point. In order for the user of the device to reproduce this, some sort of alignment function must be available in our design. This alignment system needs to consistently pinpoint that exact location in space and it needs to not inhibit any aspect of imaging. For example it should not get in the way of the imaging device. One idea proposed by Riley Pieper was the usage of lasers for the alignment.

What concerns me initially about the usage of lasers is the damaging of eyes. In order to obtain accurate data about the rats eyes they should be in good condition. Obtaining incorrect data from animal subjects is an ethical concern because it could pose severe risks to humans if incorrect conclusions are applied to treating humans. The reason for my concern is I have seen warnings printed on laser pointers about not shining them directly at eyes. The following is brief research to confirm this concern.

A. Soglin, "Is Your Laser Pointer Dangerous Enough to Cause Eye Injury?" aao.org, https://www.aao.org/eye-health/news/laser-pointer-eye-injury (accessed October 7, 2019)

Notes:
The power of a laser (milliwatts) is positively correlated with eye injury
Above 5 milliwatts, a laser causes permanent damage to the eye in a short amount of time.
Under 5 milliwatts there is enough time for someone to reflexively look away and avoid damage
Some lasers are misleading in labeling and can be more dangerous than expected
According to the FDA you should never point a laser at someone

Conclusions/action items: Using a laser on an anesthetized rodent is very likely a bad idea. Constant exposure over a long period of time, along with the inability for the rodent to react could cause extreme amounts of unintended damage. Injury to the specimen, especially the eyes that are being imaged is something we want to avoid at all costs. Additionally, lasers could even pose health concerns to the user of the device. I propose that we should explore other methods of alignment such as sights or protruding rods that meet at the center of the rotational axes.

Sketches 092419

▪ KEVIN TAN ▪ Sep 24, 2019 @10:57 PM CDT

Title: Sketch 1

Date: 9/24/19

Content by: Kevin Tan

Present: Kevin Tan

Goals: Brainstorm design ideas and provide visualization

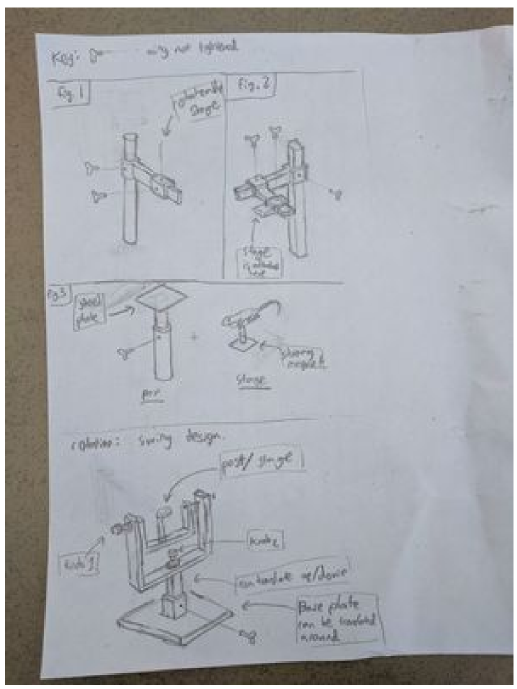
Content:

See Images below

Figures 1, 2 and 3 depict the post which holds the rodent. Each shows a different idea on how to achieve 3 degrees of translation. The last sketch shows where the post would attach onto a potential chassis. The second image is another idea for a translational plate.

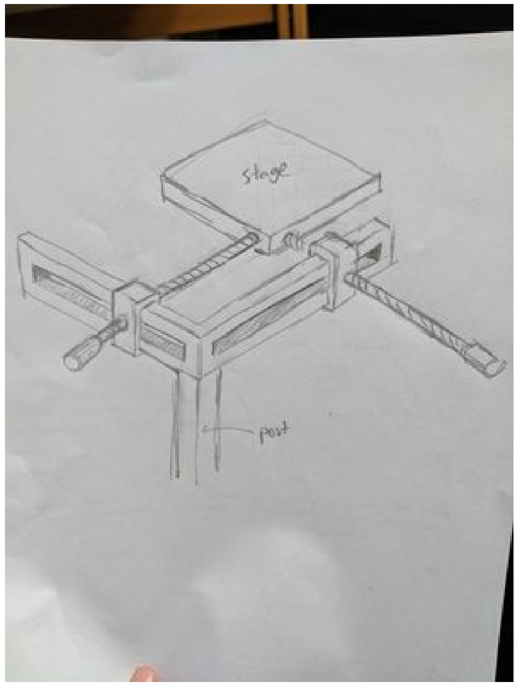
Conclusions/action items: Share ideas with group members to help them improve their designs and to receive feedback for my own.

▪ KEVIN TAN ▪ Sep 24, 2019 @01:38 PM CDT



Sketch_1.JPEG(195.6 KB) - download

▪ KEVIN TAN ▪ Sep 24, 2019 @10:56 PM CDT



Sketch_2.JPEG(152.8 KB) - download

Notes 092619

▪ KEVIN TAN ▪ Sep 26, 2019 @10:36 PM CDT

Title: Sketch 1

Date: 9/26/19

Content by: Kevin Tan

Present: Kevin Tan

Goals: Record a response I have to Riley Peiper's ideas

Content:

In response to Riley's idea of lasers to align the rodent's eye: I think this is a good strategy but I think there are some areas to investigate. First, if the laser possibly causes damage to the animal, we may not want to use it. An alternative would be to use sights. These would be harder to use but are simpler and less intrusive. A second area of concern is where the lasers would be located. While the axes of rotation would be the best place to put them, would the arms of the design be in the way? for Riley's design with tracks only at the bottom seems pretty open on the top so this could work. However, for something like the previous team's design, one of the lasers could be put above going down. the arm of the device may be in the way for the other one. My suggestion is that we don't even bother putting the lasers at the rotational axes. While it seems un-intuitive, as long as two lasers (or sights) intersect with a large angle and at a single point, it will allow the user to calibrate accurately. In fact, putting them in locations where, at least for some rotational position, both don't get blocked by the body of the rodent would be optimal.

Conclusions/action items: Share these thoughts with the group.

Sketches 100219

▪ KEVIN TAN ▪ Oct 02, 2019 @10:38 PM CDT

Title: Sketches 100219

Date: 10/2/19

Content by: Kevin Tan

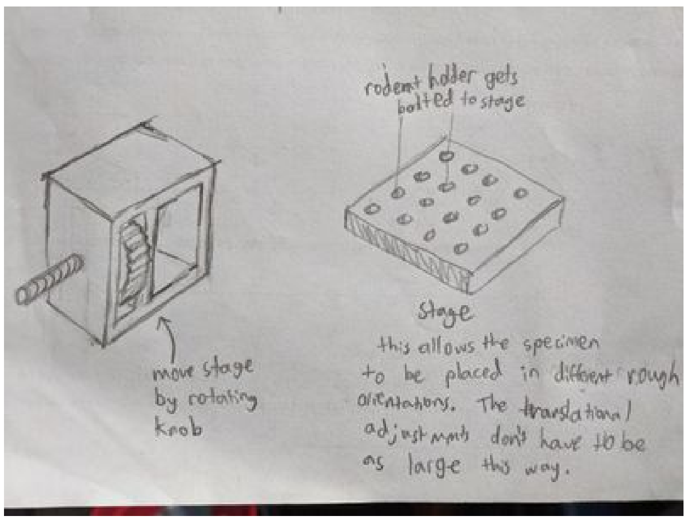
Present: Kevin Tan

Goals: Record ideas

Content:
Below are two sketches of components I want to add to my current design. The rotating knob on the left should make adjusting my fourth stage design easier (see Sketches 092419). It is also more stable and easier to construct than what the previous sketch implied.

Conclusions/action items: Consolidate my ideas to put them in the preliminary presentation

▪ KEVIN TAN ▪ Oct 02, 2019 @10:37 PM CDT



Sketch_3.JPEG(159.4 KB) - download

Notes 100219

▪ KEVIN TAN ▪ Oct 02, 2019 @11:05 PM CDT

Title: Notes 100219

Date: 10/2/19

Content by: Kevin Tan

Present: Kevin Tan

Goals: Record ideas

Content:

If the two rotational axes get misaligned during construction or during use, the entire design would have to be reconstructed. With this in mind, would it make sense to add further rotation/translation for calibration?

For a swing design, the device would naturally swing down to the lowest energy position. This would make it difficult to adjust and lock the rotation. Adding dense counterweights that don't obstruct the user could counteract this.

Conclusions/action items: Consolidate my ideas to put them in the preliminary presentation

Sketches 100319

▪ KEVIN TAN ▪ Oct 07, 2019 @06:29 PM CDT

Title: Sketches 100319

Date: 10/7/19

Content by: Kevin

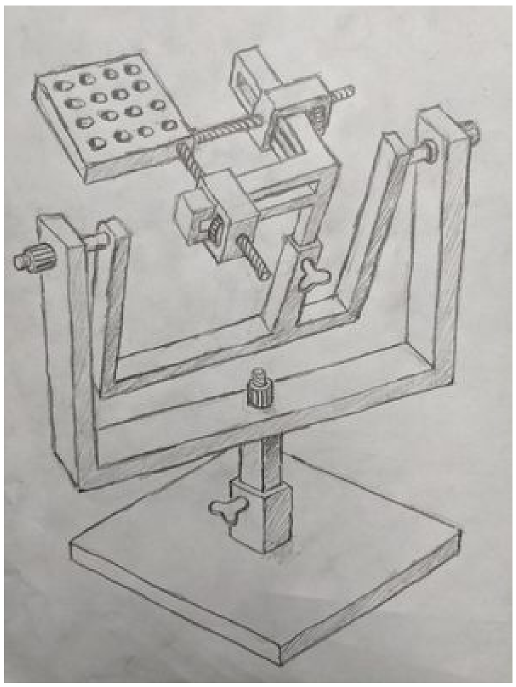
Present: Kevin, Riley, Nolan, Kyle, Kurt

Goals: Draw the Field Goal design

Content: See below image. This will be presented at the preliminary presentation

Conclusions/action items: The pizza design received the highest score on the design matrix. Still, there are design elements we can use from this design.

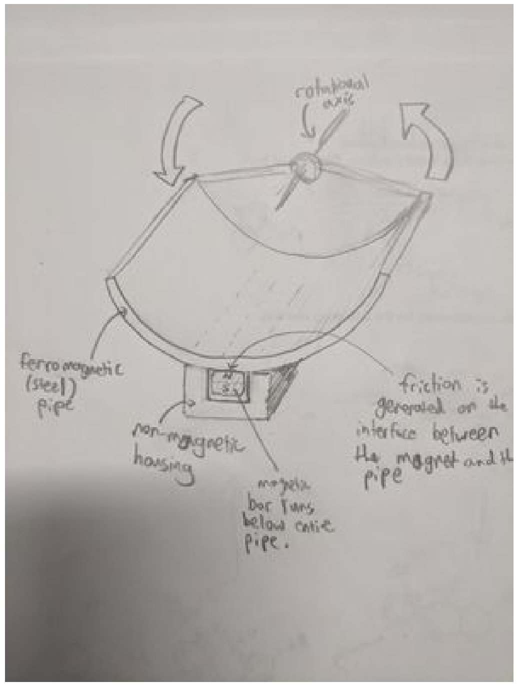
▪ KEVIN TAN ▪ Oct 07, 2019 @06:25 PM CDT



Field_Goal_Design.JPEG(256.1 KB) - download

Sketches 102419

▪ KEVIN TAN ▪ Oct 24, 2019 @01:56 PM CDT



Magnetic_Friction.JPEG(131.6 KB) - download

▪ KEVIN TAN ▪ Oct 24, 2019 @02:05 PM CDT

Title: Sketches 102419

Date: 10/24/19

Content by: Kevin Tan

Present: Kevin Tan

Goals: Brainstorm ideas for generating friction without a very precice fitting interface

Content:

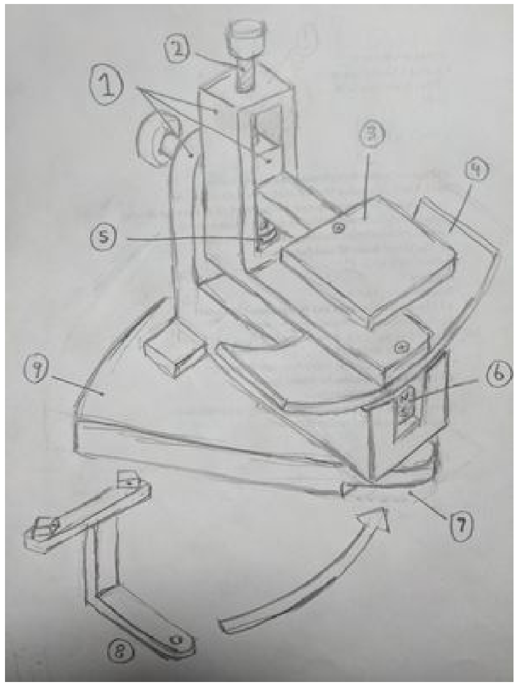
See Image below

the magnet below is very strong and will fix itself against the rotating pipe above. this means that the pipe will rotate only when the user applies a sufficient amount of force. the magnet is not fixed to any surface which means it does not need to be precicely attached. It does howver need to be fitted within the slot with a adequate amount of precision.

Conclusions/action items: Share this idea with team and decide whether magnets can be used for other parts of the design.

Materials Ideas 110619

▪ KEVIN TAN ▪ Nov 06, 2019 @11:25 PM CST



Sketch_1.JPEG(187.7 KB) - download

▪ KEVIN TAN ▪ Nov 07, 2019 @12:05 AM CST

Title: Materials Ideas

Date: 110619

Content by: Kevin Tan

Present: Kevin Tan

Goals: Get a general sense of what parts and materials we may need. Also simplify some of the shapes to make finding and machining these materials easy

Content:
Key for the image above
1. These parts need to be precisely dimensioned so they can slide past each other. Also they should be made of a non-magnetic material that is easy to mill but also is durable. Probably aluminum or a high density plastic

2. This is a threaded rod. The threads need to be tight enough to allow precise adjustments. The top portion would be un-threaded to allow free rotation.

3. This is a large steel/iron (ferromagnetic) plate. It would be larger than depicted for a wider range of adjustment. The stage would have a magnet on the bottom in order to stick to this. The friction between this metal plate and the stage would allow for easily adjusted translation. I am thinking something like this https://www.first4magnets.com/rectangular-c35/neoflex-89mm-long-x-51mm-wide-flexible-neodymium-magnetic-sheet-3m-self-adhesive-p11751#ps_1-12629

4. This is a steel/iron (ferromagnetic) pipe section. It may have to be positioned further back than depicted so that it never obscures the specimen. the piece sits on top of a v shaped channel with a magnet (see #6) to prevent free rotation and side to side movement. For this part we could use something like this https://www.jbprince.com/professional-culinary-molds/cake-ring-6-inch.asp

5. This is a bearing to allow free rotation of the threaded rod. We could also use a bearing on the top of the rod for a more precise rotation. Something simple like this https://www.mscdirect.com/browse/tnpla/35433648

6. this is a bar magnet. It should be strong but doesn't have to be anything special https://www.kjmagnetics.com/proddetail.asp?prod=BY062

7. this is a gap left in the design. It needs to be directly under the vertical rotational axis.

8. This is the alignment "sight". I tried altering it from our current shape to use less material, be more durable and be easier to fabricate. The other design would still work here. This part would probably be 3d printed or fabricated with plastic.

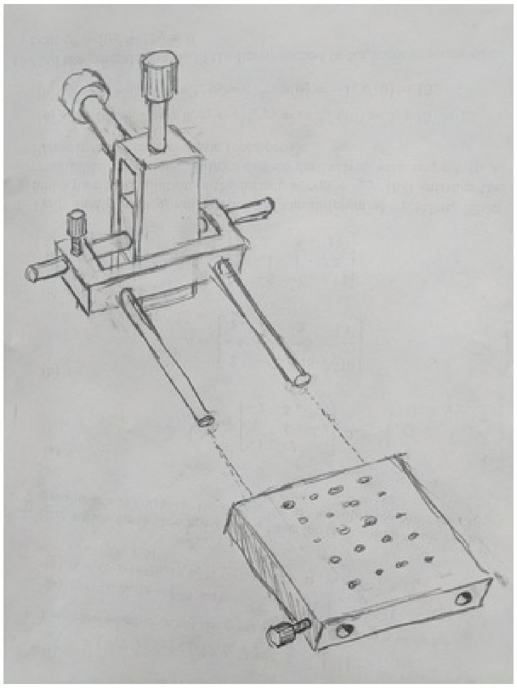
9. This is the part that gives the design the name "pizza". It should be smooth yet slip resistant. Some type of machinable plastic should work. Otherwise it could be made out of aluminum.

Conclusions/action items: We need to get materials ordered sooner rather than later. So the team needs to discuss the list of parts and materials listed above.

Fabrication Ideas 111419

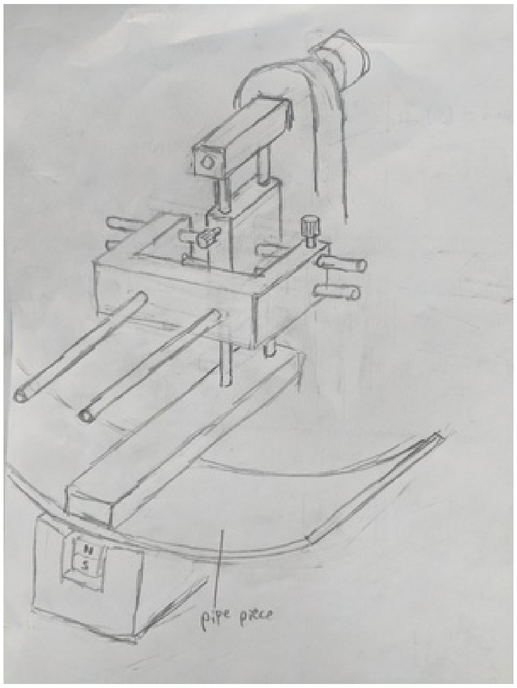
▪ KEVIN TAN ▪ Nov 14, 2019 @11:56 PM CST

▪ KEVIN TAN ▪ Nov 15, 2019 @12:06 AM CST



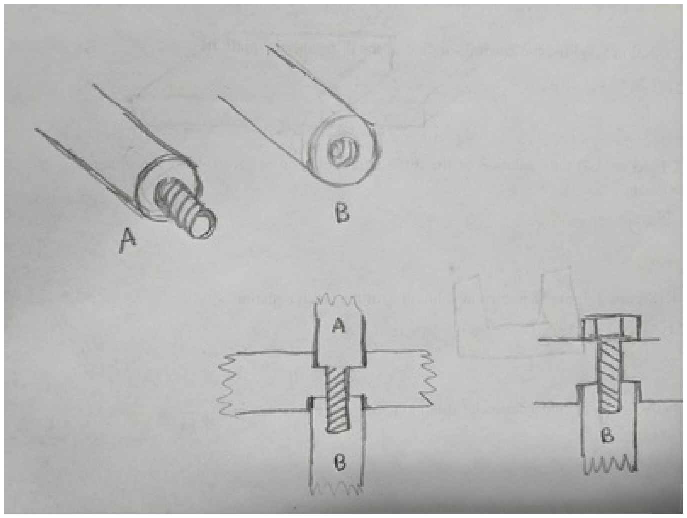
sketch1.jpg(2.6 MB) - download

▪ KEVIN TAN ▪ Nov 15, 2019 @12:06 AM CST



sketch2.jpg(2.7 MB) - download

▪ KEVIN TAN ▪ Nov 15, 2019 @12:02 AM CST



sketch3.jpg(2.8 MB) - download

▪ KEVIN TAN ▪ Nov 15, 2019 @12:32 AM CST

Title: Fabrication Ideas

Date: 11/14/2019

Content by: Kevin Tan

Present: Kevin Tan

Goals: Our current design relies on mating flat surfaces in channels. To make fabrication much easier by avoiding reliance on machining perfect surfaces, I propose a new design and method of fabrication inspired by the ideas generated at our last client meeting.

Content:
Sketch 1: this is my first idea for using rods for translation. I kept the drawing because I didn't change the stage for my next design. I omitted drawing the stage in the second sketch.

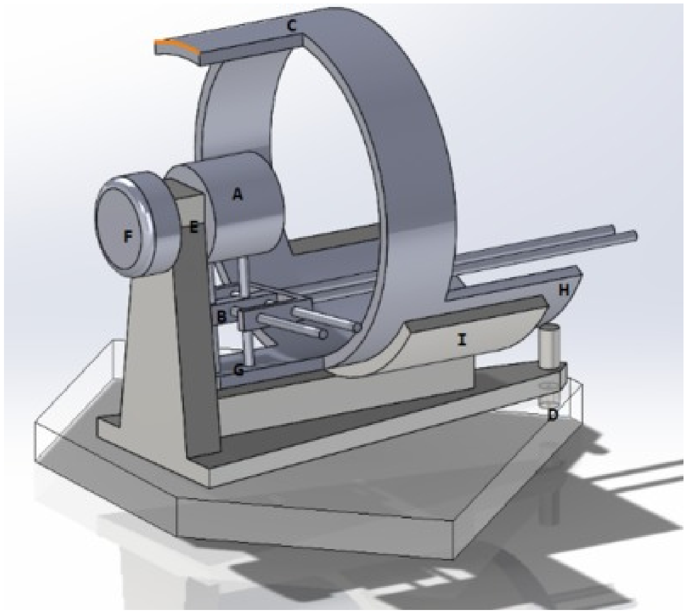
Sketch 2: this is my second idea for using rods. I included the pipe and magnet system to show how the parts are related to the rest of the design. In each direction there are 2 rods which allow for linear translation but no torsion. Thumbscrews tighten the rods down once they are in place. The parts in this sketch are not drawn to scale and some of the rods will need to be thicker/longer in the actual design. The rods will be made out of metal, likely aluminum and the blocks can be made out of a tough, high density plastic like ABS.

Sketch 3: This shows the rods seen in sketch 2. the ends of the rods will either be like A or B. In sketch 2, rods will need to travel through one of the blocks but be secured in place. To do this, a connection involving both A and B will be used. When the rods mate up against a block, B will be used in combination with a normal bolt. It is also possible to use A in combination with a nut. In both cases, the holes will be counter-bored to add extra stability and centering of the rods. Assuming no pre-manufactured items can be found, the ends of the rods can be quite easily cut on the lathe and threaded with a die/tap.

Conclusions/action items: Transfer ideas to CAD to create dimensions and fit parts.

Design Comments 112519

▪ KEVIN TAN ▪ Nov 25, 2019 @08:39 PM CST



diamond.png(156.2 KB) - download

▪ KEVIN TAN ▪ Nov 25, 2019 @08:47 PM CST

Title: Design Comments 112519

Date: 11/25/2019

Content by: Kevin Tan

Present: Kevin Tan

Goals: Make comments and suggestions on our current solidworks drawing

Content: The following pertain to the labeled image above. I will label z as up and down, x as left and right and y as into and out of the image.

A. This part does not have to be circular and it can be much smaller. This is to make fabrication easier and because we need to put threaded holes into the bottom for the rods to attach and doing this on a flat surface would be easier. I think a rectangular shape would be the best. Keep in mind, a bolt or axle goes through parts "A" , "E" and "F". this axle needs to secured on each side to ensure "A" can't slide away from "E", I think this should be included in the diagram.

B. This part should be taller. A thumbscrew needs to be accessible on this part in order to tighten it to a set position on the vertical rods. Making it taller makes it easier to place this thumbscrew. I like the new configuration of rods going through part "B" which has changed from my sketch in "Fabrication Ideas 111419"

C. My understanding is that this part is here to act as a counterweight to counter the weight of the translational elements and specimen. I think it is a good idea but if it isn't needed it should be removed because it inhibits the user's accessibility to the specimen.

D. I think this rod should go deeper into the base. The longer it is, the less likely it is to pop out and the more accurate its rotation will be.

E. This part can be sloped but i don't think it needs to have an angle right under where it is labeled "E". Another note when fabricating is that this part will have to be very accurately aligned so that the axis through E intersects the axis created by part "D" at our required point of rotation.

F. I don't think this part is completely necessary. I understand that this part is intended to allow the user to rotate the design. The problem with this is that there would need to be a rigid connection from parts "F" to "A" through part "E" which would be hard to make without relying on friction or glue. Another thing to keep in mind is using a knob reduces the mechanical advantage the user has. I think it would be easier to grasp part "C" or near "G" to rotate the design.

G. This is a connection between threaded setscrews and a pvc pipe. This kind of connection could be fairly weak. We may want an intermediate part that connects these two parts. I think a block of HDPE would work.

H. This part should be flush with part "I". If it hangs off the edge that is extra weight and material that doesn't contribute to the friction between parts "H" and "I". The other side also has a bit of overhang which i don't think it needs except for whatever is needed structurally for the connection at "G"

Conclusions/action items: Continue updating the solidworks design to match what we are fabricating. Getting dimensions planned out will speed up fabrication.

2014/11/03-Entry guidelines

▪ John Puccinelli ▪ Sep 05, 2016 @01:18 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

▪ John Puccinelli ▪ Nov 03, 2014 @03:20 PM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items: