Week #12 – Biophotonics Part 2

READ THIS A SECOND TIME PLEASE

These two weeks will allow you to: (1) learn a bit about biophotonics; (2) importantly, prepare for the final design project, which is worth a lot of points.

You have now gone through 10 weeks of lab and mastered all the basic tools in the lab, including absorbance measurements with the spectrometer. This week and next, your job will be to setup your own lab experiment procedures! I will give you lab topics, and some hints/clues for each lab.

By now you have seen how to setup a professional optical experiment and report on it. Now you will learn how to develop your own procedures and theoretical calculations. This will require as much work as a normal lab, at least, if you go to the level of detail needed! The experiments are a bit short/simpler, because you will spend more time setting up your procedure and theory. The experiments are also a bit 'messier' and open-ended, so that you can't simply look up an exact procedure or solution on-line. You will need to figure most of the procedures out!

You need to justify your work as much as possible using theoretical calculations or other defendable methods. Lack of proper details for your design, or lack of justification of your design, will cause a significant loss of points for this lab.

Lab report format is a recorded video! This is your report. So do a good job! Your team should share the presentation (each student pick a few slides to present). We will do video recordings, because (1) scheduling so many presentations is challenging; (2) it is a very effective way to quickly document your findings, and is a skill that is going to be needed more and more in the workplace.

You can use any recording device/software that allows recording of voice over powerpoint slides. I really like using a stylus and 'Explain Everything' on a tablet (Mac and Windows version available, only $3, there is also a 30 day free trial). Powerpoint also has audio/video record as well for your laptops.

Again, I expect to hear from everyone in the group. You likely need to record it a few times to get it right (Explain Everything lets you conveniently redo just one slide). Please, export only to MP4 or MOV format (not AVI, etc.) and no more than 1024x768 pixels. No exceptions else you will receive a zero for your grade.

Also, adhere strictly to the time limits. Practice it, and redo the recording if needed. Getting your message across in a clear, CONCISE and fully informed manner, is a talent that will accelerate your careers more than you think. Your supervisors are busy, and when you present at large meetings there are many people there whose time is valuable. It is upon you to prepare, polish, and deliver concisely (but with all key information there, of course).

Part 2 – Week 12 – Artificial Human Eye **–** Goal: using mainly parts in the lab, determine feasibility to make an artificial (bionic) eye. This is something researchers are now working on, they are making detectors and also tunable lens systems that can be implanted into the body! Please note, what we are doing is also the basic requirements for making a camera! This part 2 for biophotonics will also require you to be a bit more creative, so we are preparing you for the final lab where you can pick any project.

Due date – the following Monday by noon, uploaded to blackboard.

Human pupil diameter: ~3-10 mm maximum, typically a bit less as the iris gets older

Human eye focus range: 0 to 40 diopters (m^{-1}) which is just the inverse of focal length change from infinity to ~25 mm

Human retina area: ~ 22 mm in diameter (7 million cones, ~75-150 million rods)

A possibly helpful video: http://www.youtube.com/watch?v=gvozcv8pS3c

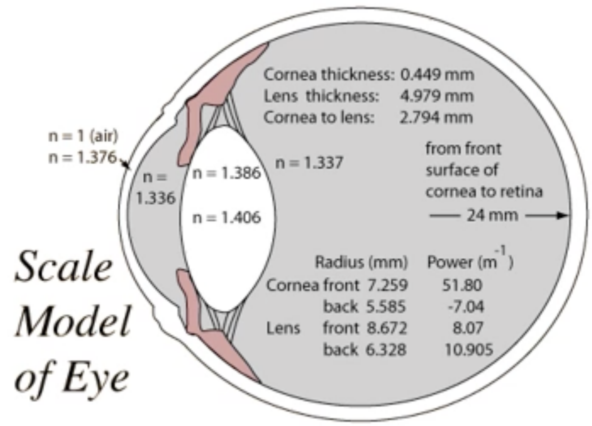
Experiment Part 1: First, build a very basic artificial eye using:

1. *the tunable iris found in the components bins, or a piece of black paper with a hole in it (your choice, the black paper can be closer to the lens). With the lights on in the room, do tests with and without the iris to show how the iris is important to human eye function. If you make the iris work well, you will cover your lenses and the imaging sensor w/ black paper or foil so that only light comes in through the iris. This way you can perform most of the experiments in a well lit room.*
2. *several lenses of different focal lengths, you may also try to use the manually tunable opto-tune lens in the parts bin, or the voltage tunable electrowetting lens (bit more difficult as it is smaller in diamter).*
3. *the bare USB controlled CMOS imaging chip (just use your laptop and treat it as a USB camera, block or remove the blue LED light from the imaging chip);*

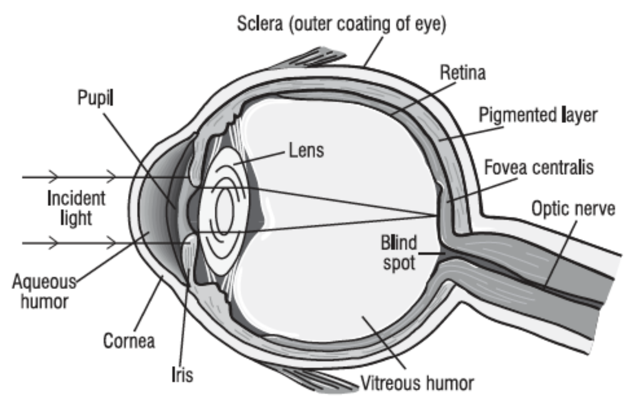
Once your 'eye' is assembled and working, adjust and/or switch out the components so you can focus on objects at several distances away, and perform lens calculations that support your observations.

(4) Add one or more lenses to increase the magnification and do a calculation of theoretical magnification you expect for your system (now make it a 'bionic eye', capable of more than you started with!). There are several ways to do this (think telescopes and beam expanders…). Here is one example that is more than what you need to do:

https://dl.dropboxusercontent.com/u/25943618/Permanent%20Course%20Links/6048%20Video%20Tutorials/Additional%20Magnifcation.mp4



When you are measuring, remember you must shield the CMOS imaging chip from any stray light or use a dark room except for what you are trying to image. You could use a cell phone or laptop screen in the dark room, with several screen images, and move the camera phone to several distances to show focusing and defocusing, and magnification, of the image onto the CMOS imaging chip. A white card or printed image on white paper, that is VERY brightly illuminated, might give the best results. The USB chips are meant for typically room lighting and a wide-angle lens (so not very sensitive, as they typically receive lots of light!). Your goal is to show function that is similar to the human eye and have experimental data/images to justify this.



<u>Experiment Part 2:</u> Next, gain a rough estimate of how sensitive the human retina is (<u>your actual eyes</u>) compared to conventional photodetectors. Figure out a procedure to quantitatively determine how much more sensistive your human retina is than the Newport photo detector. Try to make some quantitative (data driven) observations that find limits of detectable powers for the human retina, and for the photodetector, then compare them. You will find that the human eye is amazingly sensitive. As a hint, you might try to 'detect' dim images in a dark room.

<u>Presentation:</u> Your 5-6 minute video-recorded presentation (if is more than 5-6 minutes, it will not be graded!) should use the slide templates and fonts we use for lectures in the class. You should have 4-6 slides, no more, which include:

1. Title, group name, statement of project goal.
2. Description and theory of how the human eye works (<u>include</u> key optical equations and optical parameters).
3. Experimental setup and results for focusing at long and short distances (experiment data <u>and</u> theory/calculations).
4. Experimental setup and results for sensitivity (experiment data <u>and</u> theory/calculations).

Again, you must cover ALL details such that someone else would need if they were to EXACTLY reproduce your work. Also, your design and theoretical calculations must be easy to understand for everyone (the Professor, and other students). You also must justify your designs and conclusions you make with legitimate calculations. It would be further beneficial to provide <u>your own</u> simple ray-trace diagrams that articulate how your artificial eye works.

A note of warning – based on previous video submissions:

This is from past years, don't make it so I have to give very poor grades and send this out this year too!

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Optics students,

I will start sending out the grades and comments for Week 11 videos.

Few comments:

1) Most groups did a very poor job following instructions, left out key calculations. Half of you did not even do a video, which was clearly stated in the requirements.

2) Most groups did not give adequate experimental details. Can someone really reproduce the results you show based on the info you give them? Think of all the variables at play. Think of how different results were from group to group. Your experiment details should let someone get the SAME results that you did, basically. That is the purpose, so in the future, someone can EXACTLY repeat your experiment and get the SAME results. If you don't give that level of detail, then a lab report (in industry is a technical report) is useless. Results, if not documented well, are of no value, if others cannot reproduce them (if you can't reproduce them, you can't use them). Hope you see the point I am trying to make....

3) Most groups needed a deeper theoretical explanation. Most presentations were the level you would present to non-engineers. Your audience is other engineers. You need to provide them with the theoretical tools they would need also to understand the fundamentals of the experiment.

Anyway, this is the warm-up. Next week, will expect improved video reports, and by the time of the final video report, they will all be good ;) This is why you get to do it 3 times...

All the best,

-JCH

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