

Problem Definition

Motivation:

The electroretinogram (ERG) has been used to diagnose a number of eye diseases (Figure 1). Retinal physiology can also reflect systemic disorders such as liver and kidney disease¹. Currently, there is a need for many new drugs for eye disease to be developed and tested. An ERG provides an optimal research environment because tests can be conducted on an isolated retina (Figure 2), which allows various solutions to be in contact with the sample. Although systems exist for the measurement of ERGs in animals, it is important to create a computer program that will help integrate components of a given test design and allow researchers to visualize and analyze their data.

Figure 1: ERG recordings in a normal patient and one with retinitis pigmentosa².

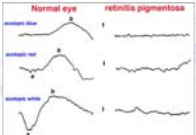


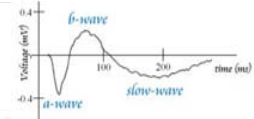

Figure 2:
Example of a
mouse retina³

Background:

The ERG measures the electrical responses to light of various cell layers in the retina⁴. Electrodes on the retina, after light stimulation of varying wavelength and frequency, identify a triphasic wave. The a-wave, b-wave, and slow wave create the wave form, representing different layers of the retina. Chemical solutions that block various cell types are flushed over the retina in order to isolate cell layers, making it easier to distinguish problem areas¹. (Figure 3)

- A-wave – reflects the physiological health of photoreceptors in the outer retina
- B-wave – reflects the health of the outer cell layers of the retina
- Slow wave – provides information on the bipolar and ganglion cells^{2,5}

Figure 3: Example of an ERG wave¹. The a-wave is negative, the b-wave is positive, and the slow-wave is negative. The b/a wave ratio is a good indicator of ischaemia, or insufficient blood flow in a central retinal vein obstruction⁵.



Design Criteria

Problem Statement:

A computer interface will be designed to integrate aspects of research design with ERG data acquisition and analysis. These aspects include liquid exchange through valve control and incorporation of a logarithmic light wheel along with the need to export data files and graphs to a separate program to store the information in a simple and organized format.

1. Operational Characteristics

- Record:
- Record filter number (light intensity)
 - Flash duration
 - Sample duration
 - a-, b-, and slow-waves

- Include:
- Noise reduction
 - Timestamps
 - Liquid delivery through valve control – one solution at a time only of 8 different solutions
 - Checkpoints in graphs

2. Production Characteristics

- Text easily readable
- Contrasting colors
- Intuitive organization
- Simplicity

Abstract

The electroretinogram (ERG) records voltage responses of the retina in response to light stimuli. This project's goal was to design an interface in LabVIEW that would monitor, control, and record values from the ERG corresponding to liquid delivery, light intensity, flash duration and frequency, and voltage responses. We integrated all of these controls while updating the graphical user interface (GUI) so that it was easy to navigate in a dark room under a red filter. Up to eight different solutions can be delivered, and only one solution is delivered at a time. Light intensity is controlled by setting a number on a filter wheel through the interface. An option to export data to Microsoft Excel is included along with real-time graphs. All relevant functionality present in a previous version of the interface was preserved, and input points were organized into tabs so that real-time graphs could be enlarged and the interface did not look cluttered. The new interface is functional on the client's setup and provides the capabilities to properly record and analyze the ERG.

Final Design

In the backend, a sub.vi has been created which stores the data recorded by the electroretinogram into two columns: time and voltage. Additionally each of the user-selected settings for a particular test is stored in the header.



Figure 4: Previous LabVIEW interface lacks:

- Ability to change light intensity
 - Options to set and change solutions to be delivered
 - Option to export data
- The interface also looked cluttered

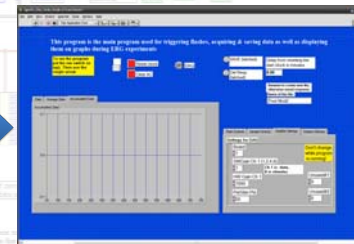


Figure 5: Current LabVIEW interface adds features that were lacking

Control of the solution delivery valves is separate from the testing controls but has also been integrated into the GUI for convenience. Control for the light wheel has already been built into the program. However, due to the late arrival of the wheel, it has not been tested yet.

Modifications have been made to the GUI (Figures 4,5) according to design principles⁷:

- Tabbed windows have for controls decreased clutter
- Tabbed windows for the graphs allow for a larger display
- Colors have been modified to increase readability with and without a red filter⁸.
- Cursors have been added to locate points on graphs in real time.

Testing

Save Feature

Saving data is an important feature and this component has been tested by sending data (time and value) and verifying that the results open in Excel and are accurate (Figure 6). The headers are located on the top two rows, followed by the data below.

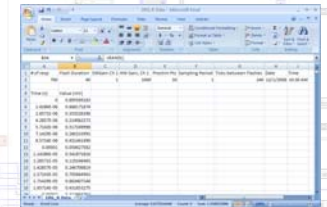


Figure 6: Sample Output File

User Interface

The new colors were tested behind a red filter to verify a high level of contrast (black for background, white for foreground) while allowing a minimal amount of light through. The testing environment can be seen in figure 7.



Figure 7: The location that testing is performed – a rat retina is placed on a microscope slide to record the ERG. The retina is then perfused with drugs through the liquid delivery system.

Future Work

Software features have been implemented with the knowledge that the hardware is going to be added in the near future. These include a light wheel that controls the intensity of light shining on the retina and a valve delivery system to perfuse solutions over the retina.

References

- Medline Plus. 2008. "Electroretinography." US National Library of Medicine. <<http://www.nlm.nih.gov/medlineplus/ency/article/003388.htm>>
- Creel, D. 2008. "Clinical Electrophysiology." John Moran Eye Center, University of Utah. <<http://webvision.med.utah.edu/ClinicalERG.html>>
- MedicineWorld.org. 2005. Light-sensing cells in retina. <<http://medicineworld.org/news/news-archives/ophthalmology-news/July-9-2006.html>>
- Green and Kapousta-Bruneau. 2006. "Evidence that L-APS and D,L-APH can preferentially block cone signals in the rat retina." *Visual Neuroscience*. 24(1):9-15.
- Ye JH, Goo YS. 2007. "The slow wave component of retinal activity in rd/rd mice recorded with a multi-electrode array." *Physiol Meas* 28:1079-1088.
- Matsui, Y et al. 1994. Electroretinogram b/a wave ratio improvement in central retinal vein obstruction. *British Journal of Ophthalmology*. 78(3):191-8.
- Hobart, J. "Principles of good GUI Design." <http://www.iie.org.au/Monitor/v01n03/ar_2_1hc2.htm>
- Morton, JL. 2008. "Color Theory." <<http://www.colormatters.com/colortheory.html>>

Acknowledgements

We would like to give special thanks to:
Dr. Bikash Pattnaik, Professor Mitch Tyler, Professor Tom Yen, Amit Nimunkar