Matlab Modeling of Retina Anatomy and Function

Academy Engineering
Jason Farina, Janelle Cordero, and Adenibi "A.J." Curry
Eric Hogle, Consulting Engineer

Dr. Vikram Kapila, Project Advisor
Mechatronics Laboratory
Department of Mechanical Engineering, NYU Polytechnic
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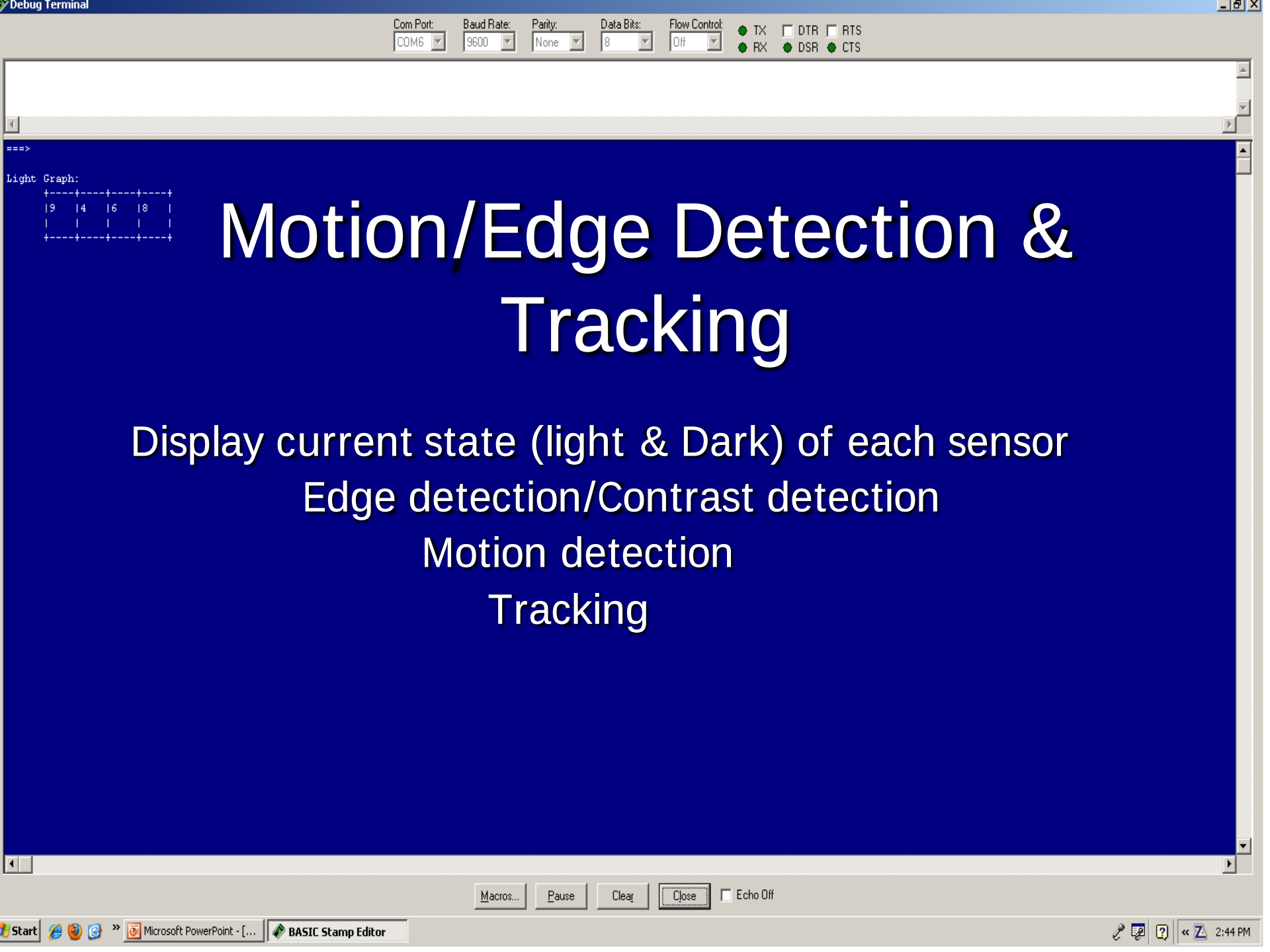
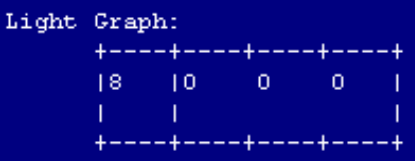
Background

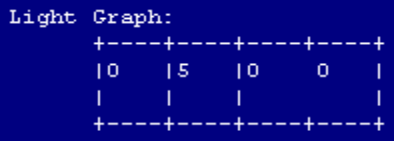
- Explosion in research at intersection of engineering and medicine
- Neuro-Robitics is an emerging field
  - Brain-controlled smart prostheses
  - Retinal implants
  - National Geographic: Biorobotics
- Personal interest in neuroscience, brain function, and sensor systems

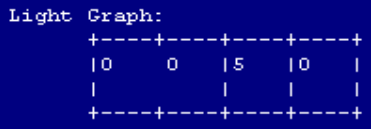
Purpose: Retina Model

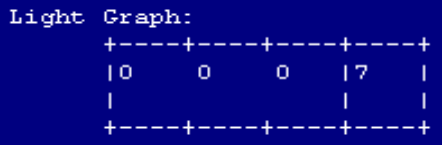
- To capture function by modeling form
- To develop a research tool to provide insight into the structure of the retina
- To develop simplified image processing algorithms
- Future development of jOcular Implant


Debug Terminal
Com Port:
COM6
Baud Rate:
9600
Parity:
None
Data Bits:
8
Flow Control:
Off
TX
RX
DTR
DSR
RTS
CTS
===>
Light Graph:
|9 |4 |6 |8 |
Motion/Edge Detection & Tracking
Display current state (light & Dark) of each sensor
Edge detection/Contrast detection
Motion detection
Tracking
Macros...
Pause
Clear
Close
Echo Off
Start
Microsoft PowerPoint - [...
BASIC Stamp Editor
2:44 PM



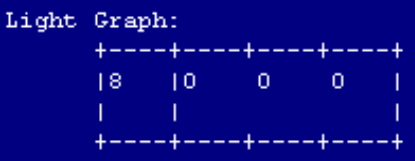


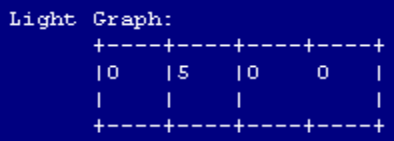


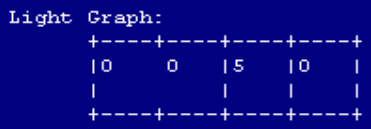


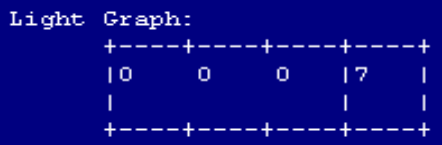
Algorithms

- Rc-Time scaled 0-10, then displayed using debug command.
- Takes the difference of adjacent readings and asks IF they are greater than 2, if so THEN display a line.
- Debug command displays the diffx value in ASCII code which will display a vertical line or an empty space.



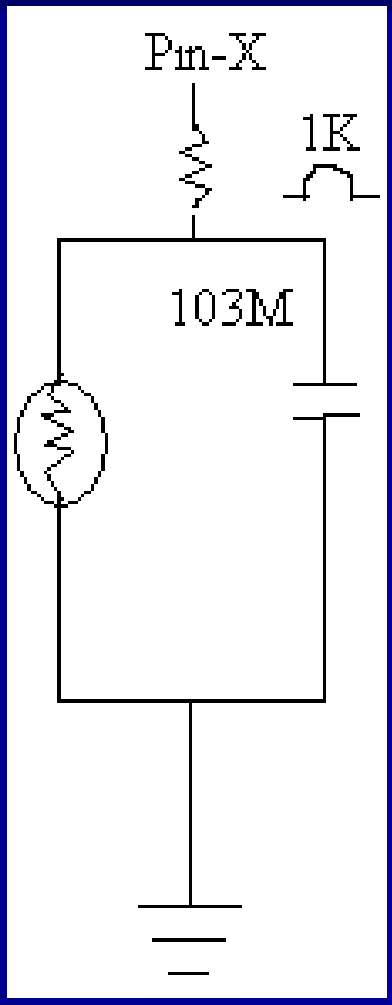






Circuit Anatomy

- The RC-Time is used to display the light levels in the specified area.

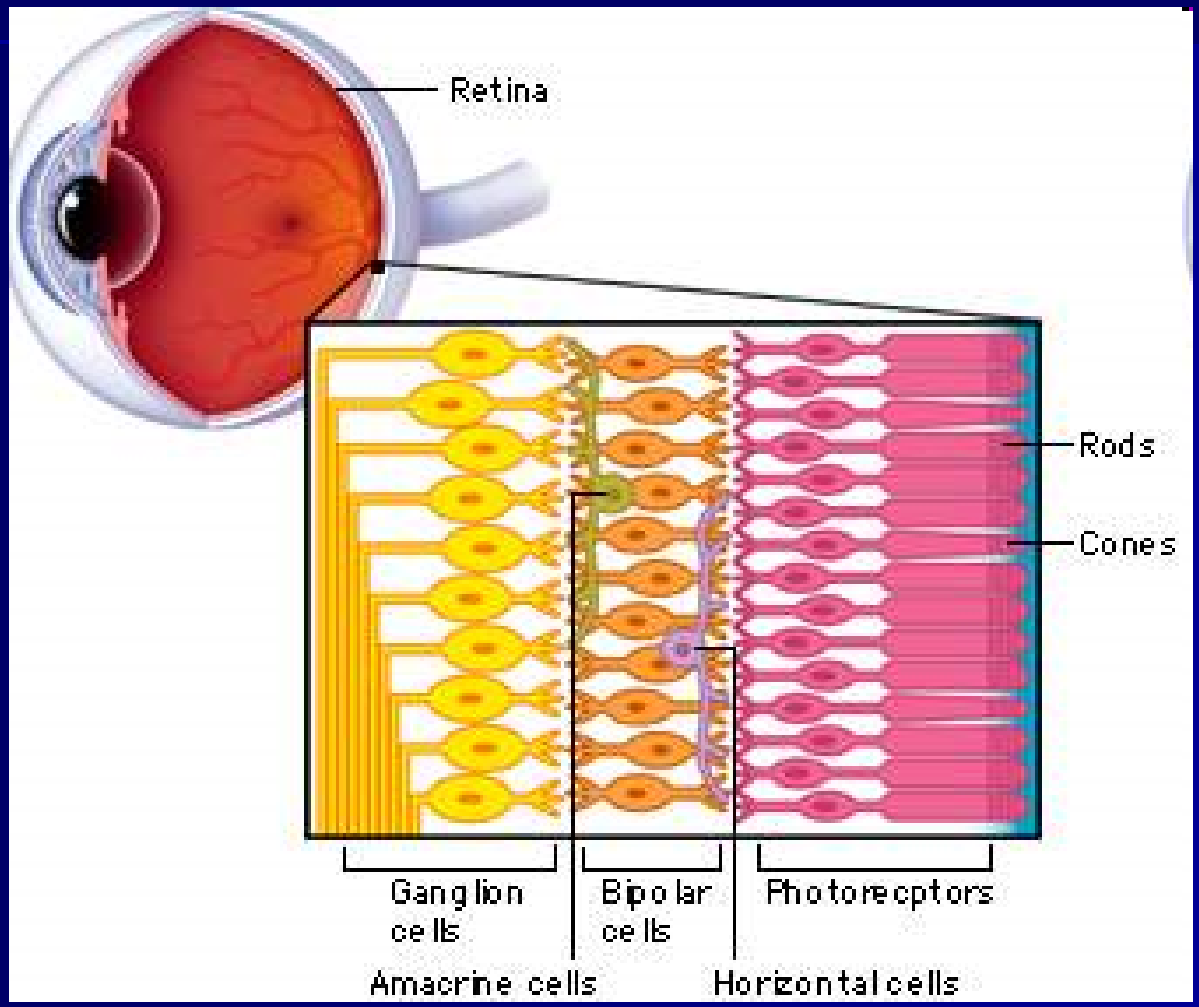


Model Overview

- **Build the eye**
  - Constructing each layer of the retina (Photoreceptors, Bipolar, and Horizontal cells)
  - Connections between the layers
  - Using matrices to display each cell and their locations
- **Image processing**
  - Contrast
- **Difficulties**
  - Switching from manually to automatically inputting the video
- **Data/Results**
  - Displaying image

- **Future Directions**

Retina Cell Layers



Building the eye

- Constructed different layers of the retina
- Photoreceptors occupy the entire retina
  - Cones are about 10 times larger than rods
- There are fewer horizontal cells than photoreceptors
- Bipolar cells occupy the same locations as the horizontal cells

Array Editor - PhotoreceptorArray

Stack: Base

	1	2	3	4	5
1	1	1	1	1	1
2	1	1	1	1	1
3	1	1	1	1	1
4	1	1	1	1	1
5	1	1	1	1	1
6	1	1	1	1	1
7	1	1	1	1	1
8	1	1	1	1	1
9	1	1	1	1	1
10	1	1	1	1	1

←Photoreceptor Array

Horizontal/Bipolar Array→

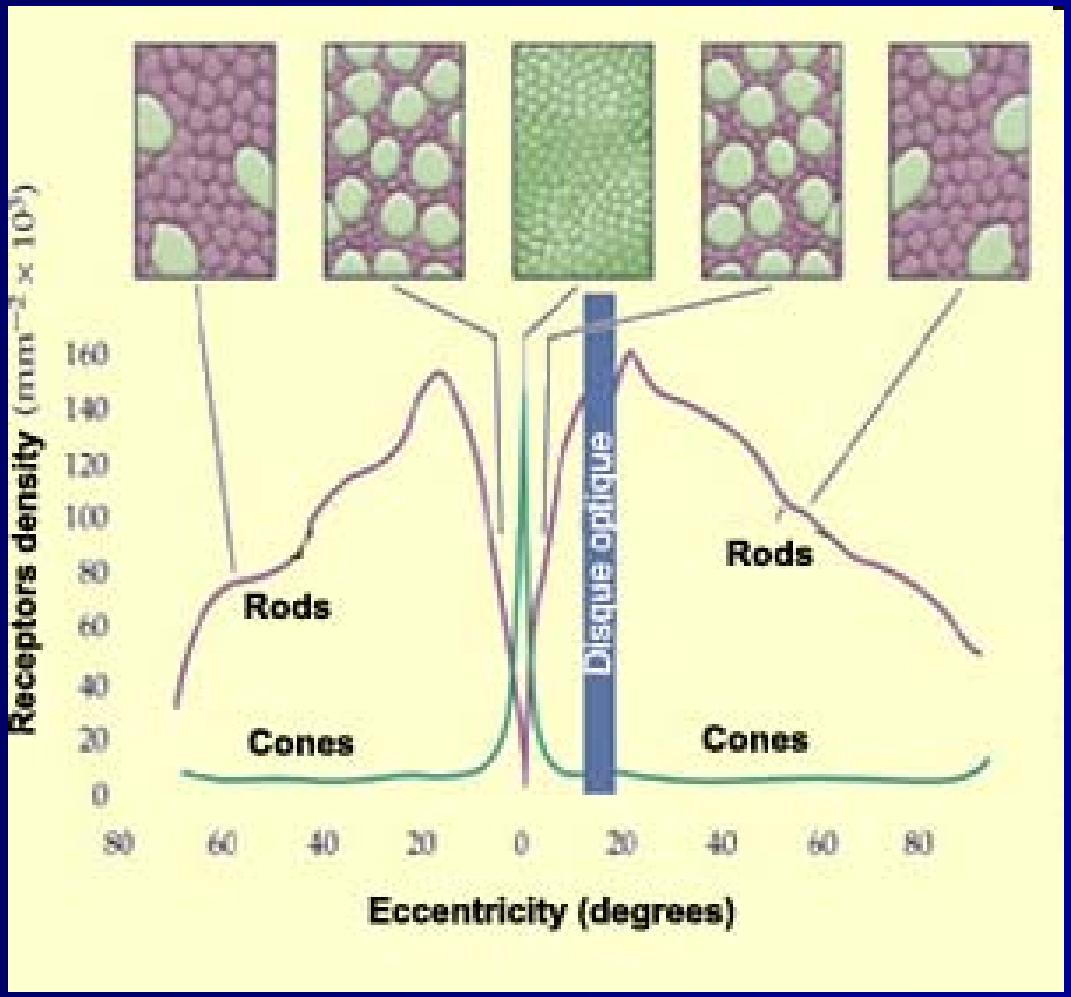
Array Editor - BipolarArray

Stack: Base

	1	2	3	4	5
1	1	0	1	0	1
2	0	1	0	1	0
3	1	0	1	0	1
4	0	1	0	1	0
5	1	0	1	0	1
6	0	1	0	1	0
7	1	0	1	0	1
8	0	1	0	1	0
9	1	0	1	0	1
10	0	1	0	1	0

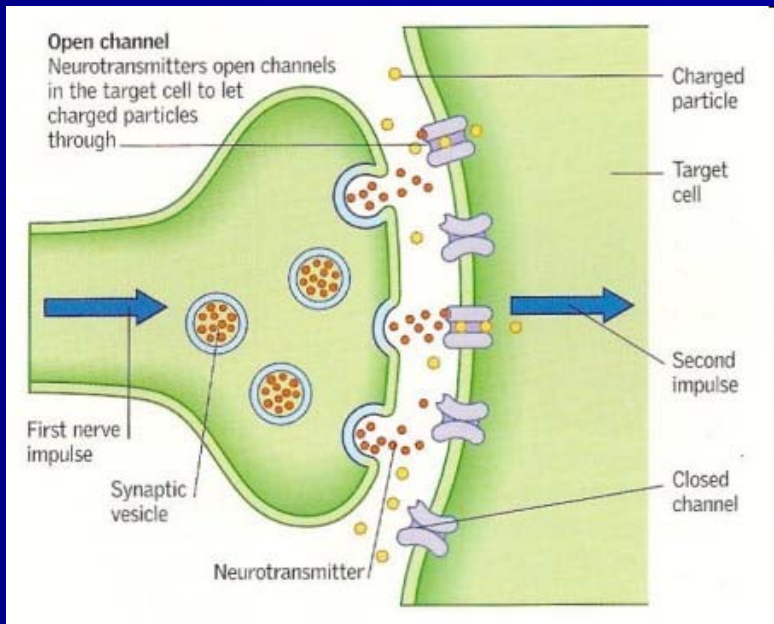
Building the eye

- Distribution of Rods and Cones in the Retina

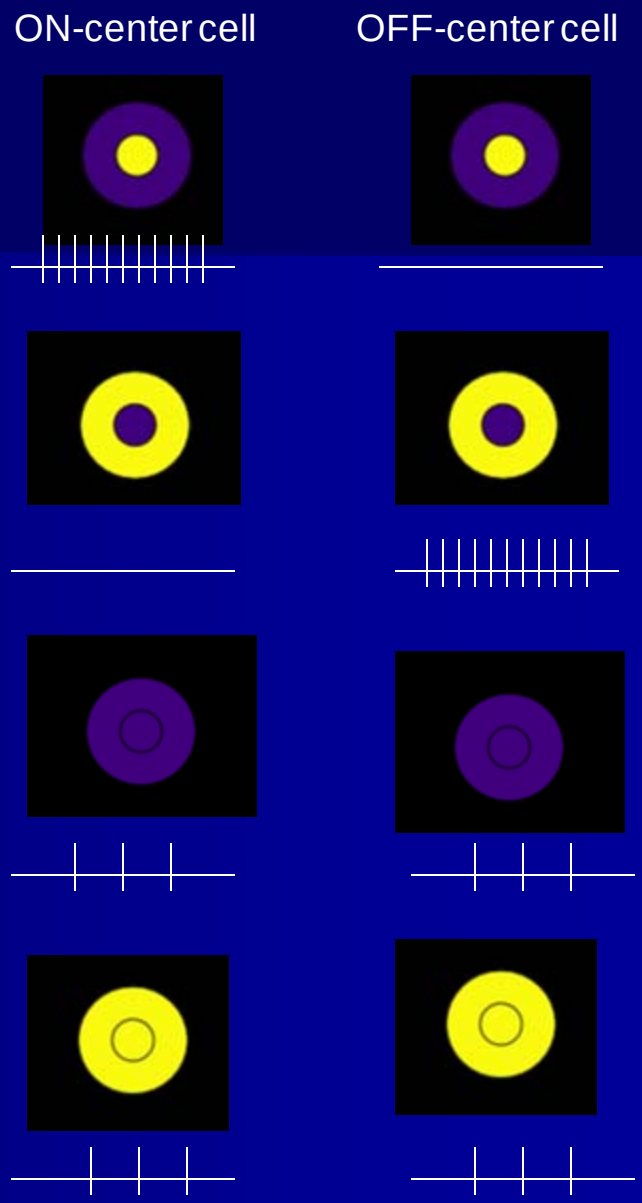


Building the eye

- Creating connections between the cell layers
- Photoreceptors must be able to communicate with the horizontal and bipolar cells in order to send messages to the brain
- Neurotransmitters send signals between layers



Center-Surround Structures



SIMULINK Model

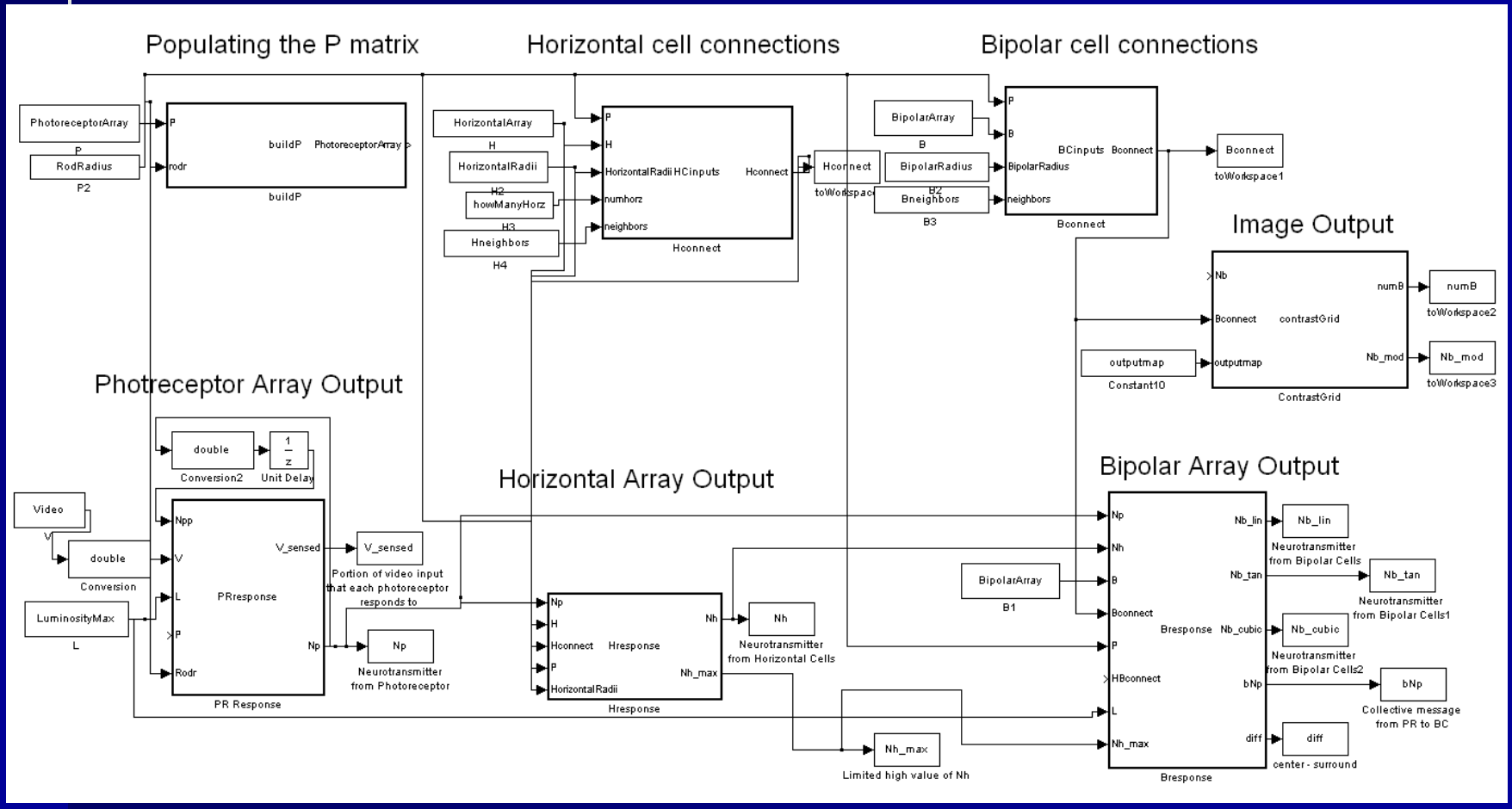
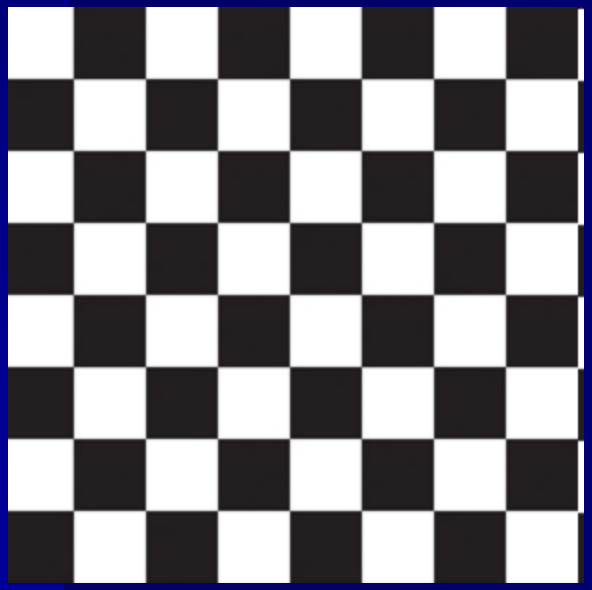


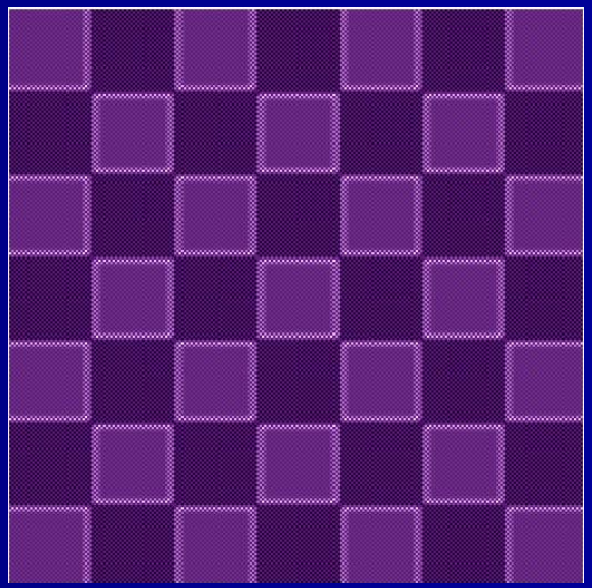
Image Processing

- The eye must be able to detect contrast

Input



Output



A few difficulties

- Scaling
- Output graphics
- Embedded matlab function use a limited function library
  - Ex: nnz

Future

- Color
- Scaling
- Validating model using clinical data
- Modeling amacrine and ganglion cell connections