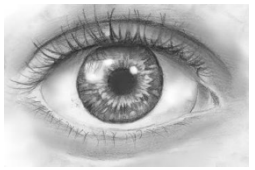
W1005
Intro to CS and Programming in MATLAB

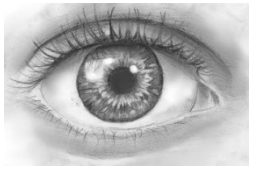
Project Lecture (2)

Fall 2014

http://www.cs.columbia.edu/~vovsha/w1005



Cataract Catcher

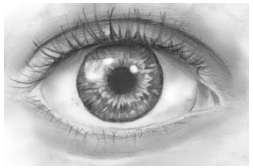


Problem Summary

- WHO: 285 million visually impaired people worldwide [1]
  - 246 million people with weakened vision

- Cataracts - leading cause of weakened vision
  - Natural - proteins in the eye clump
  - Distorts images sent to the retina
  - Clouds the lens opposite the pupil
    - Primary symptom

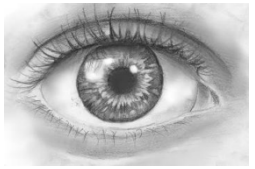
- Main Goal: Create a preliminary cataract diagnostic software via MATLAB
  - Utilize a user-friendly interface to provide diagnosis and resources



[1] Brian, Garry and Hugh Taylor. World Health Organization. Cataract blindness - challenges for the 21st century. France: Soregraph. (2001). Web.

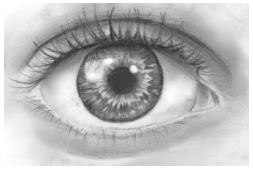
Solution Approach

1. User uploads a picture (JPEG, TIFF, PNG) of their eye for analysis
    a. User sees a preview of their image before confirmation
2. User selects the pupil of their eye in their picture for analysis
    a. Allow the user to zoom in/out of the picture to select the pupil
3. Analyze the user-selected region-of-interest (pupil) for a cataract
    a. Compare grayscale index value of the pupil's pixels to threshold values
    b. Compare the pupil's overall opacity to threshold values
4. Provide a preliminary cataract diagnosis to the user
    a. Provide online resources based on their diagnosis

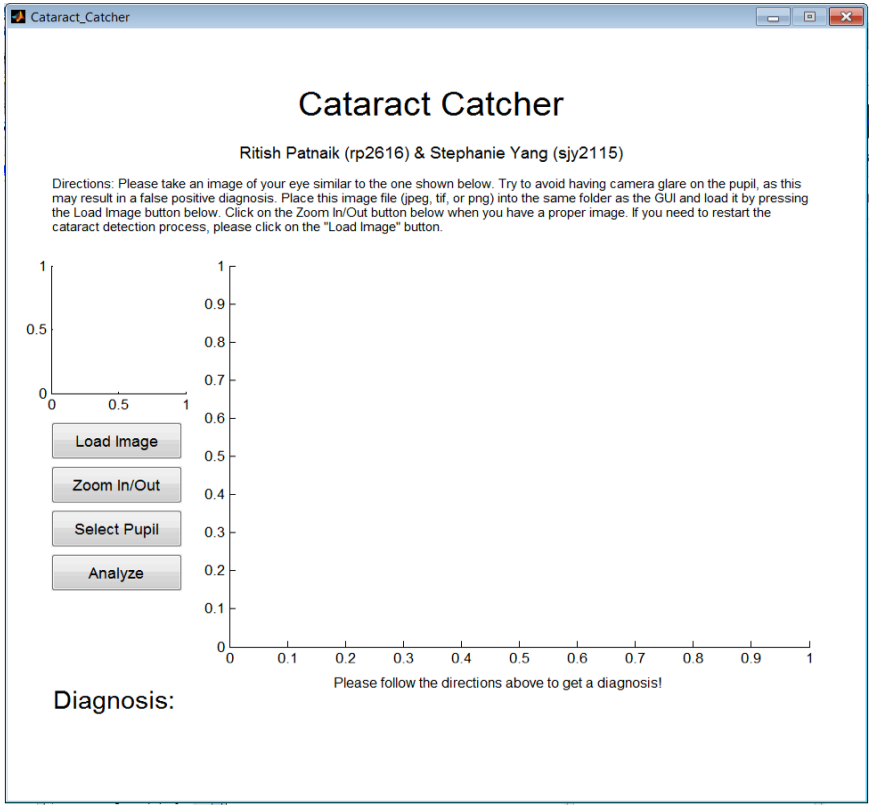


Solution Approach

- Assumptions:
  - Uploaded image is taken in good lighting
  - Accurate selection of pupil
- Want the user to select pupil by hand
  - Creation of user-friendly interface to allow for more accurate selection

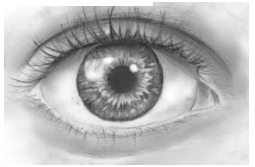


Step 0: Setting Up the GUI

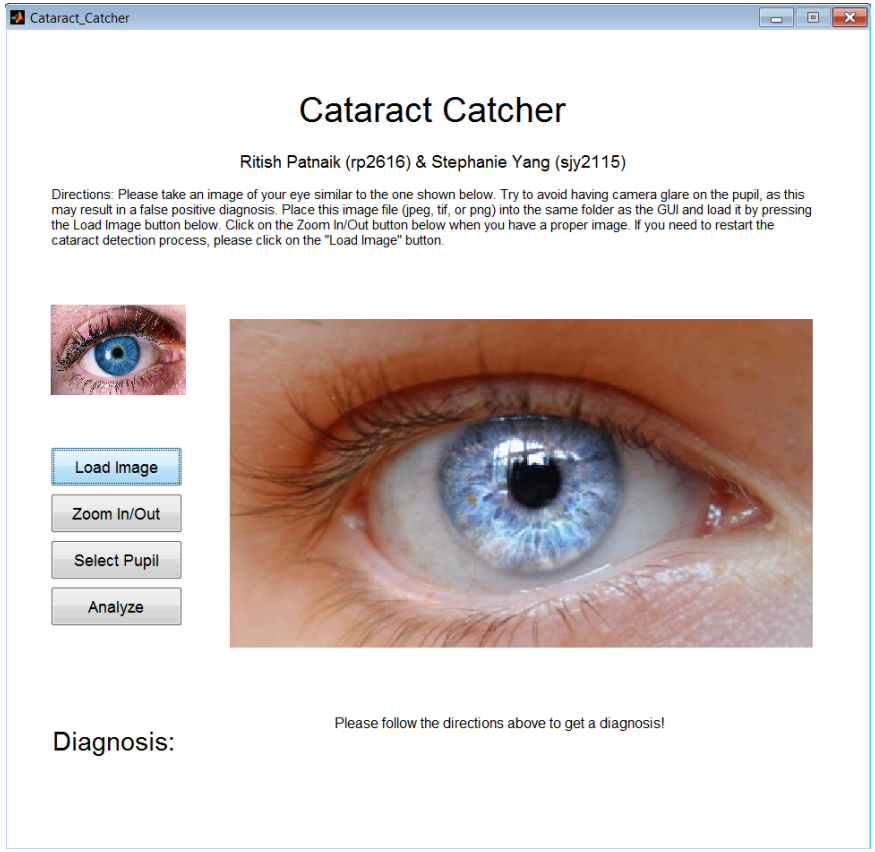


- Generated with GUIDE
- Demo image shown on smaller set of axes
- Tick marks hidden on larger set of axes

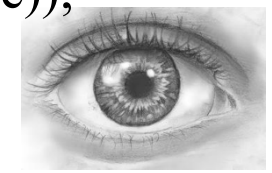
```
axes(handles.demo_pic);
imshow(imread('demoeye.jpg'));

axes(handles.uploaded_pic);
axis off;
```



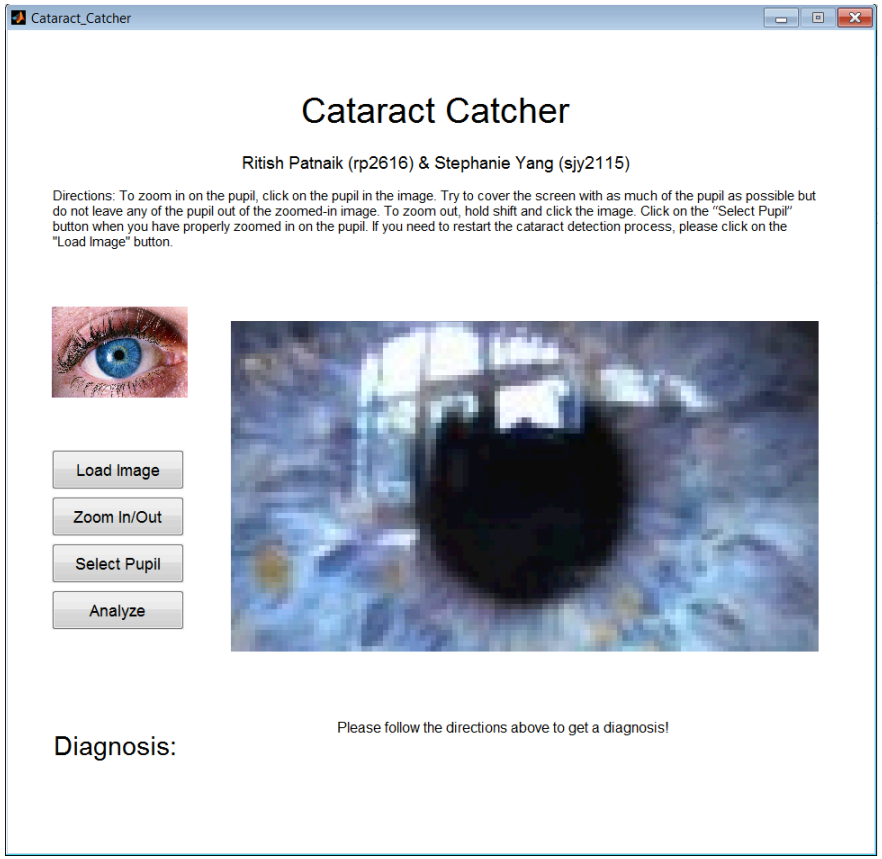
Step 1: Loading an Image



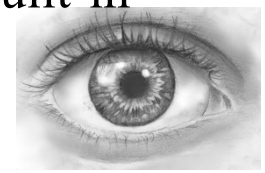
- Buttons arranged in step-by-step order
- Clicking the load button opens up a modal dialogue box that allows the user to select an image file
  - im_file = uigetfile (‘*.jpg;*.tif;*.png’);
- Image preview shows up on main axes
  - imshow(imread(im_file));



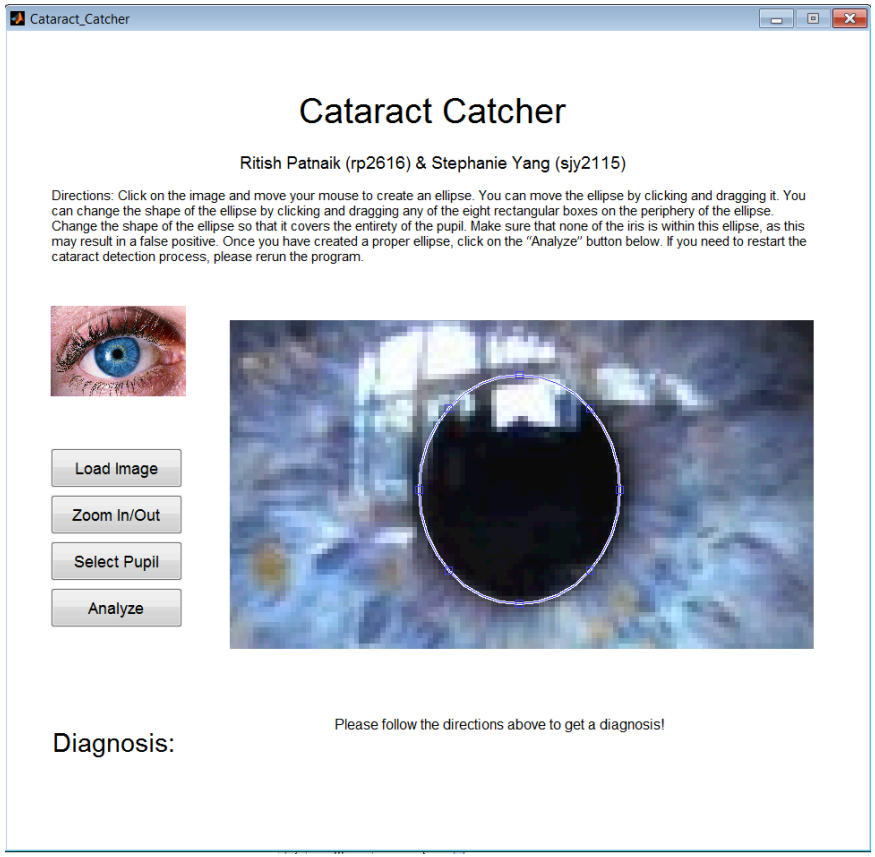
Step 2a: Zooming In/Out



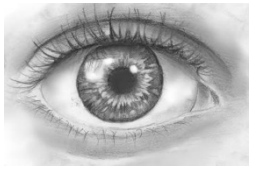
- Clicking Zoom In/Out button changes directions shown
  - set function used on handles.Directions
- Asks the user to cover the screen with as much of the pupil as possible
- Click to zoom in, shift-click to zoom out
  - zoom on; zoom off – built-in function



Step 2b: Selecting the ROI/Pupil

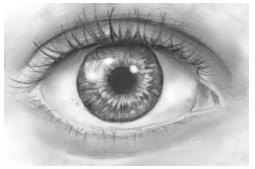


- Difficulty automating pupil selection → Image Processing Toolbox
- Clicking select pupil brings up a set of crosshairs
  - imellipse – built-in function



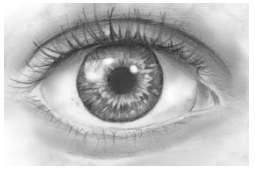
Step 3: Analyze Image for Cataract

- Retrieve position and size of ROI
  - getPosition – returns the minimum x-coordinate, y-coordinate, width and height of the ROI as a vector
- Obtain number of pixels that make up the ROI
  - Area of an ellipse
- Conversion of image to grayscale for easier analysis
  - rgb2gray
- Used a binary mask to isolate ROI



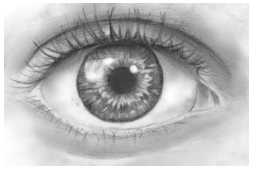
Step 3: Analyze Image for Cataract

- Applied threshold values to each pixel in isolated pupil region
  - for loop
  - $40 < x < 165$ – counted pixels with a grayscale index value within this range
- Calculated the cataract pixel density by using the number of "cataract" pixels over the total number of pixels in the ROI



Step 4: Provide a Diagnosis

- CPD > 0.3
  - Positive diagnosis
  - set – change diagnosis text; pause – countdown; web – opens up a zocdoc webpage with recommendations to eye doctors
- 0.2 < CPD <= 0.3
  - Warning zone
  - Same functions as positive diagnosis
- CPD <= .2
  - Negative diagnosis
  - set - turns on visibility for “Cataract Effects” button, set – changes diagnosis text

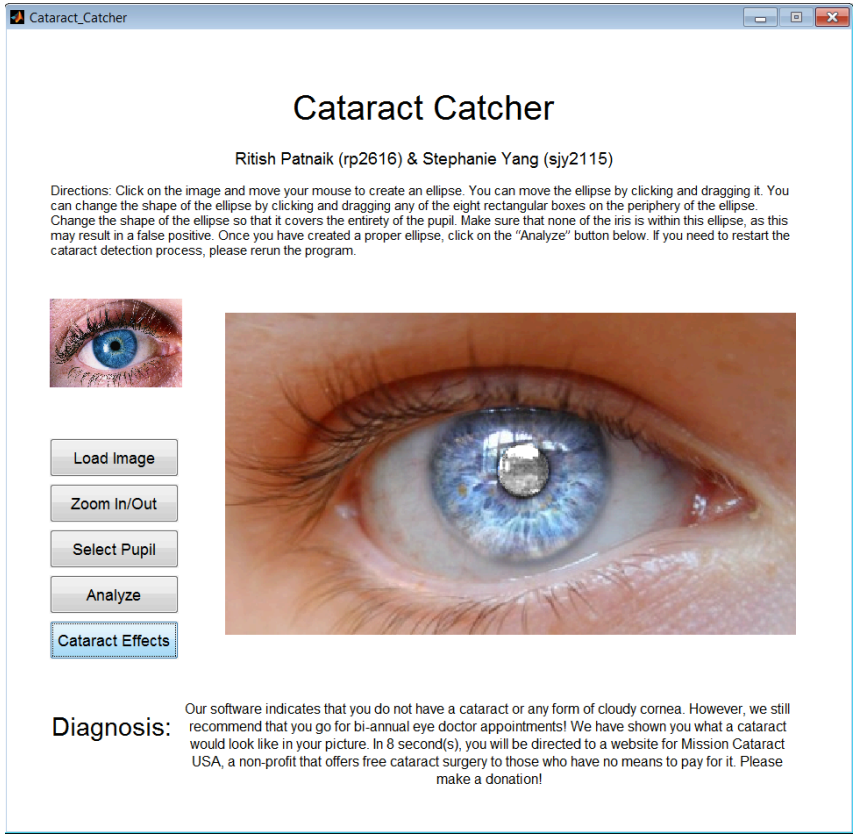


Step 4: Provide a Diagnosis

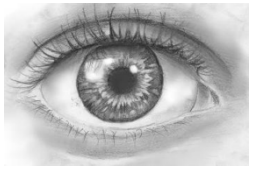
Positive Diagnosis

Negative Diagnosis

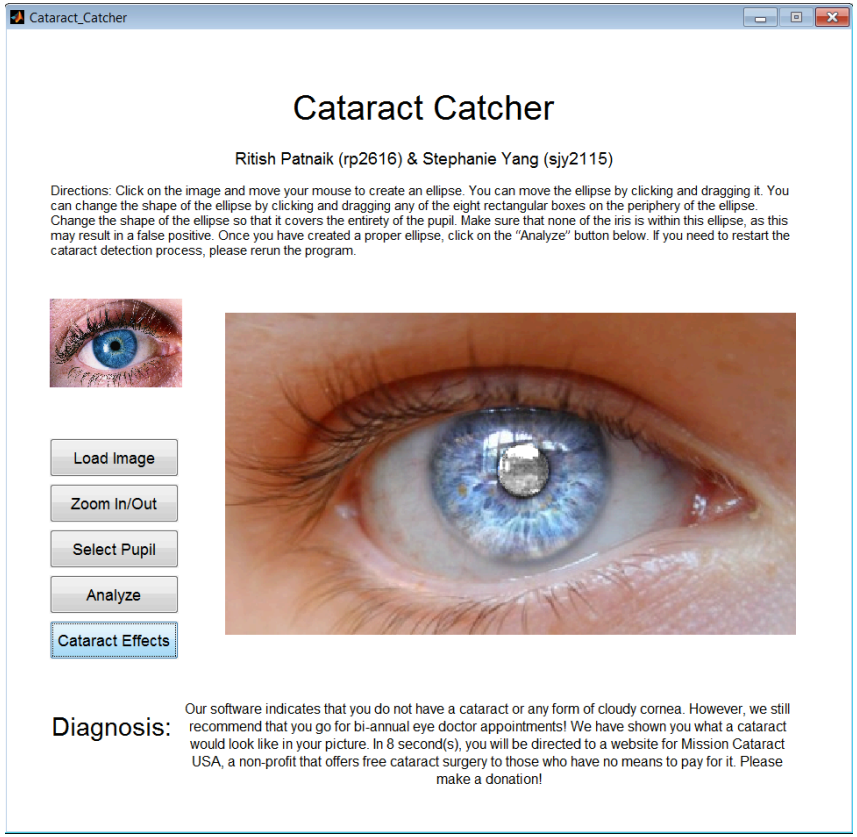
Negative Diagnosis - Cataract Simulation



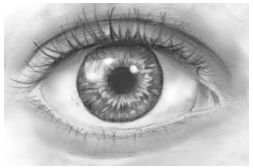
- Negative diagnosis causes "Cataract Effects" button to pop up
- Clicking "Cataract Effects" simulates cataract formation on selected ROI
- Gradual lightening of pupil



Negative Diagnosis - Cataract Simulation

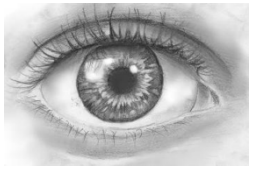


- Tried to identify a way to keep the rest of the picture from being affected
  - Creation of custom mask
  - Takes the average of only RGB values inside the ROI to convert that area to grayscale



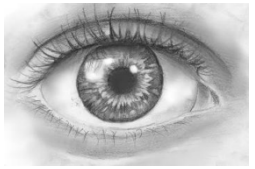
Negative Diagnosis - Cataract Simulation

- Divided ROI into different rings for fade
- Multiplied index values of the innermost circle by the greatest number
- Multiplied index values of the outermost ring by the smallest number
- pause – set to 0.01 s per iteration → allows for gradual fade
- Following simulated cataract, diagnosis text indicates that the user will be directed to www.missioncataractusa.org to make a donation
  - Offers free cataract surgery to those who have no means to pay for it



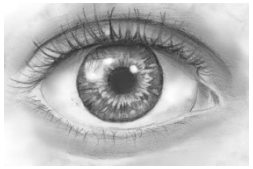
Selecting the Threshold Values

- Separate script to obtain threshold values
- Ran threshold tests for twenty images
  - Ten cataracts (cataract index values)
  - Ten normal eyes (glare/pupil index values)
  - Maximum: 165; Minimum: 40
  - imellipse
- Found “Cataract Pixel Density” thresholds
  - Ran tests for same twenty images – calculated density using same process as in main code of GUI
  - Used Index Value “Cataract Pixel” Thresholds



Selecting the Threshold Values

- Used two or three unseen images to test obtained thresholds
  - Gave correct diagnoses
  - Indication, not proof
- Drawbacks
  - Need many more images to increase accuracy of thresholds
  - Time-consuming – cannot do this for a image database
  - Edges of glare regions/pupil selection factored into index thresholds



Future Objectives

- Convert this code to Java and Python for educational purposes
  - Teach BMEs/CSers how programming can be used for disease diagnostics

- Build an iOS/Android application to bring this program to a larger audience
  - Raise awareness of the dangers of cataracts
  - Fundraise for Mission Cataract USA