Feature-Based Classification of Mouse Eye Images

Jenny Yuen, Yi Li, and Linda Shapiro

This work is sponsored by the NIH Interdisciplinary Center for Structural Informatics. National Library of Medicine under grant No. P20 LM007714

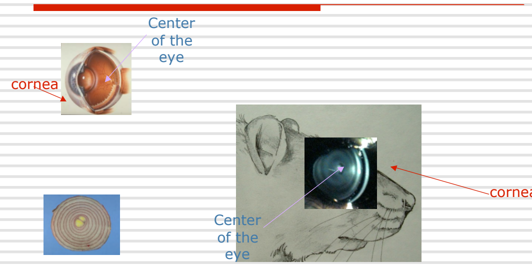
Problem

- "…A cataract is a clouding of the eye's lens."
  - The University of Michigan Kellogg Eye Center
- There are ideas associating them to other illnesses.
- Different cataracts have different effects.
- The classification is currently manual.
- This involves a lot of time and knowledge in the area.

Problem Statement

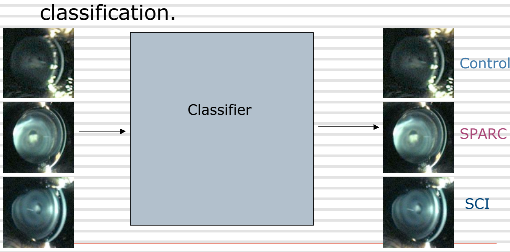
- We are given:
  - $\{C_1, C_2, \ldots, C_n\}$ classes of cataracts and for each class C_i:
    - A set of mouse eye training images exhibiting the corresponding cataract.
  - A test image *I* that is not in the training set.
- We want:
  - A classifier that can determine the class C_I, to which *I* belongs.

Eye Image



Proposed solution

- Automate the classification.



Training Data

- Labeled images for each category

Approach

- Feature Detection
  - Ring Extraction
  - Intensity Curve
- Training

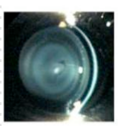
Local/Histogram Equalization

- Histogram equalization:
  - Reassigns brightness of pixels to achieve near equal numbers of distinct intensity values.
- Local equalization
  - For each pixel p in the image:
    - Take a subimage from window w around p
    - LocalEq[p] = HistEq(centered at p using w)[p]

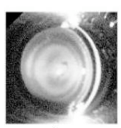
Ring Enhancement

- Use local equalization to enhance rings.

original

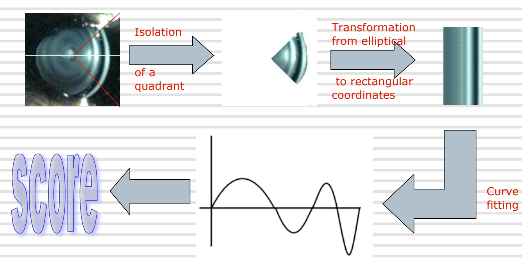


histogram equalization



local equalization

Ring Feature Extraction



Ring Detection (2)

- Take a horizontal axis x that passes through the middle of the image (row nrows/2).
  - For each pixel $p_{(x,xi)}$ in row x,

    1)Take the region of the image in the circular sector C_i with center $p_{(x,xi)}$ and central angle θ.

    2) Map this circular sector to a rectangle R using a polar coordinate transformation.

    3) Represent each column of R by its average intensity.

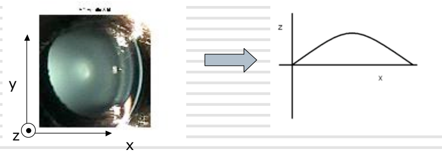
    4) Compute the variance of the intensities in this curve. This is the score for $p_{(x,xi)}$.

Ring Detection (3)

- Let L_{best} be the curve to which the circular sector with the highest score was mapped.
  - Create a feature vector with the following information from L_{best}:
    - Number, mean, and variance of maxima.
    - Number, mean, and variance of minima.
    - Mean and variance for the distance between every two consecutive maxima.
    - Mean and variance for the distance between every two consecutive minima.

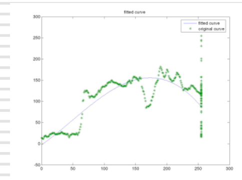
Intensity Curve Feature

- The intensity curve of a line through the center of the eye with respect to the plane described by the image.



Intensity Curve (2)

- We could use the coefficients of Fit_C as features to describe each class.
- Problem: Noise in the image might affect the polynomial.
- Solution: Use the Fourier Transform



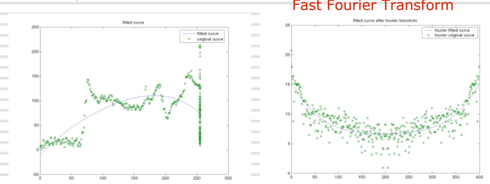
Intensity Curve(4) – Modified Algorithm

- Let *P = {p| p is a pixel in the row r/2 in the image I}*
- *C(x) = {Intensity(I(r/2,x))}*
- Apply a Fourier Transform to *C*: *Fourier(C)*.
  - Fit a polynomial on *Fourier(C)*. Call this polynomial fitting $Fit_{Fourier(C)}$.
  - Use the coefficients of $Fit_{Fourier(C)}$ as features.

Intensity Curve(5)

Intensity values

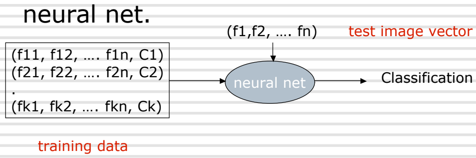
With the application of a Fast Fourier Transform



{$coeff1_{Real}$, $coeff1_{Im}$, $coeff2_{Real}$, $coeff2_{Im}$, $coeff3_{Real}$, $coeff3_{Im}$, $coeff4_{Real}$, $coeff4_{Im}$}

Training

- Using the features from a training set, we can input this data in a neural net.



Preliminary Results on 3 Classes

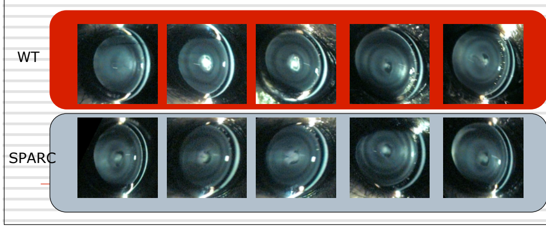
382 images	
Correctly classified	82.7 %
Incorrectly classified	17.2 %
χ2	473.44
p	≤ 0.001

Predicted

Actual	SCI	SPARC	WT
SCI	103	1	2
SPARC	1	122	32
WT	0	30	91

Confusion between images

- Some of the images are so similar to each other that it is very hard, even for an expert, to determine the class.



Conclusions and Future Work

- Performance depends on features.
- Features vary depending on the classes.
- We have:
  - Good performance identifying the SCI class.
- We want:
  - Better performance between SPARC and WT classes.
- Future work might involve human cataract classifcation.