Abstract
Otitis Media, an ear infection present in children, is one of the most commonly misdiagnosed infections in the country; a large contributing factor to this is the use of otoscopes with the naked eye for diagnosis. Recently, digital otoscopes have been created that give the doctor the option of taking digital images that can then be examined more closely and in greater detail. The objective of this senior design project was to develop a program in MATLAB using already existing image processing kernels and techniques, which would determine if an infection is present and whether it is Acute Otitis Media or Otitis Media with Effusion. This will provide a reliable second opinion for a physician to make his diagnosis. Images taken by Dr. Tulio Valdez from Hartford Children’s Hospital with digital video otoscopy devices were used in this project. Filtering techniques, segmentation, light levels, analyzing several biological landmarks that are characteristic of this infection were all used to create a final product that can detect Otitis Media with reasonable accuracy.

Background
- The middle ear consists of the tympanic membrane, cavity, and bones
- Otitis Media is the inflammation of the middle ear and can be separated into two categories:
  - Acute Otitis Media (AOM) – the ear becomes filled with a thick fluid
  - Otitis Media with Effusion (OME) – the tympanic membrane becomes inflamed and bulges outward
- Diagnostic Uncertainties include:
  - Difficult to distinguish between OME & AOM
  - AOM is frequently over diagnosed

K-Means Clustering
- The ability to segment out the auditory bone often rules out the presence of an infection
- K-Means color based segmentation is used to determine if the bone is visible
- The image is separated into specified number of clusters and grouped based on the Euclidean distance between each point and the centroid of the cluster
- Cluster 3 is further filtered and evaluated to determine if the ear is healthy or unhealthy

Central Concavity
- The presence of a donut-like shape is the main characteristic of AOM
- After filtering, this part of the program allows a physician to manually zoom in on the circular abnormality and place a cursor in the center
- Then the pixel intensity is evaluated at that specified point
- If the intensity is less than the threshold, this indicates AOM is present
- If the intensity is greater than the threshold, this indicates no central concavity

Vascularity
- Branching vascularity is a prominent feature in OME, whereas in AOM parallel alignment of vessels is present along the donut
- Matched filter detection is used to detect piecewise linear segments of blood vessels
- The green channel in the RGB image is selected for processing, and after the filter kernel is applied only the maximum of the response is retained
- Based on the range of the response, categorization of the infection type is made

Bubble Analysis
- The presence of bubbles is the main characteristic of OME
- This part of the program uses double thresholding to reveal all possible bubble-like shapes
- They are then segmented out and filtered by pixel diameter and area to determine the final number of bubbles present
- This is an accurate indicator of OME

Results
- Training set: 23 images
- Testing set: 10 images
- 9/10 images were correctly diagnosed
- 90% accuracy rate

Truth Table for Results
- The truth table for results represents the process by which a healthy ear, OME, or AOM was detected through the MATLAB program

REFERENCES & ACKNOWLEDGMENTS
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