**DE-33 (DCE)**



**NUST COLLEGE OF**

**ELECTRICAL AND MECHANICAL ENGINEERING**



**EYE EXPLORER**

A PROJECT REPORT

DE-33 (DCE)

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In the name of Almighty Allah, the Most Gracious and the Most Merciful

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### **Abstract**

Human Eye is the most complex part of the human body but it helps to reveal information about several diseases. Among these diseases are Anemia and Cataract. Anemia is a condition in which there is a deficiency of hemoglobin in the red blood cells, whereas cataract is an eye disease that causes clouding of the eye lens that causes permanent blindness if not treated in time. Anemia is diagnosed by measuring hemoglobin by drawing blood from the body and Cataract is diagnosed by first dilating the pupil and then examining the eye in the slit lamp. Both of the above methods are invasive that involve direct contact with the human body in one way or another. Computer Aided Diagnostic (CAD) systems with their mobility of usage in low resource settings can be very useful for the detection of Anemia and Cataract. We have put forward an idea in the form of mobile application named EYE XPLORER that determines the user’s risk of being anemic or having a cataract just by taking a picture from a smartphone camera. The user for the diagnosis of anemia first lowers his/ her conjunctiva and takes image and then our method first localizes the conjunctiva region from the image. Localization bins are formed to assess the hemoglobin value that further assesses the degree of anemia. For the diagnosis of Cataract, the user takes a picture of his/her eye with retina in focus. Then our proposed method localizes the iris and the pupil of the eye. Texture analysis of the obtained image is performed enabling us to tell whether the eye is normal or it has a cataract. The system is developed and tested using locally gathered dataset of anemia and cataract.

**Chapter One**

**Introduction**

Information Technology has advanced a great deal in the past few decades. It has taken place in our lives as a core component. One of the important parts of IT is Digital Image Processing. It is surprising to find the applications of image processing in almost every professional field and it has helped a lot to make processes easier. While image processing has found its use in industry, it has also played an important role in the research and development.

Before the advancement of technology, diagnosis of a disease was expensive and had large probability of error. Some of the diseases couldn’t even be diagnosed due to the limitations of the lab equipment. Whatever equipment was present was expensive and rare. The doctors would perform different tests to see the anomalies but they still couldn’t get very accurate results.

Digital Image Processing has revolutionized the field of medical sciences. It can be used in diagnosis, monitoring, and treatment of diseases. Many diseases are nowadays diagnosed using the concepts and techniques of image processing. It has made diagnosis relatively cheaper and much more accurate than before.

To make things easier, studies are being made to use noninvasive methods to diagnose a disease. Nowadays, Gadgets and other mobile applications are being developed to help ease the process of daily health care, so that a person can, while remaining in his house, do an overall checkup of his/her body. A good example can be the Apple’s new Health application that comes with its products.

Human eye can be a source of diagnosing many diseases like Cataract, Anemia, Diabetes, Glaucoma, high cholesterol, Conjunctivitis etc.

**Motivation**

Human eye is an organ which can portray many diseases. Two of the most important diseases that can be diagnosed through eyes are Cataract and Anemia.

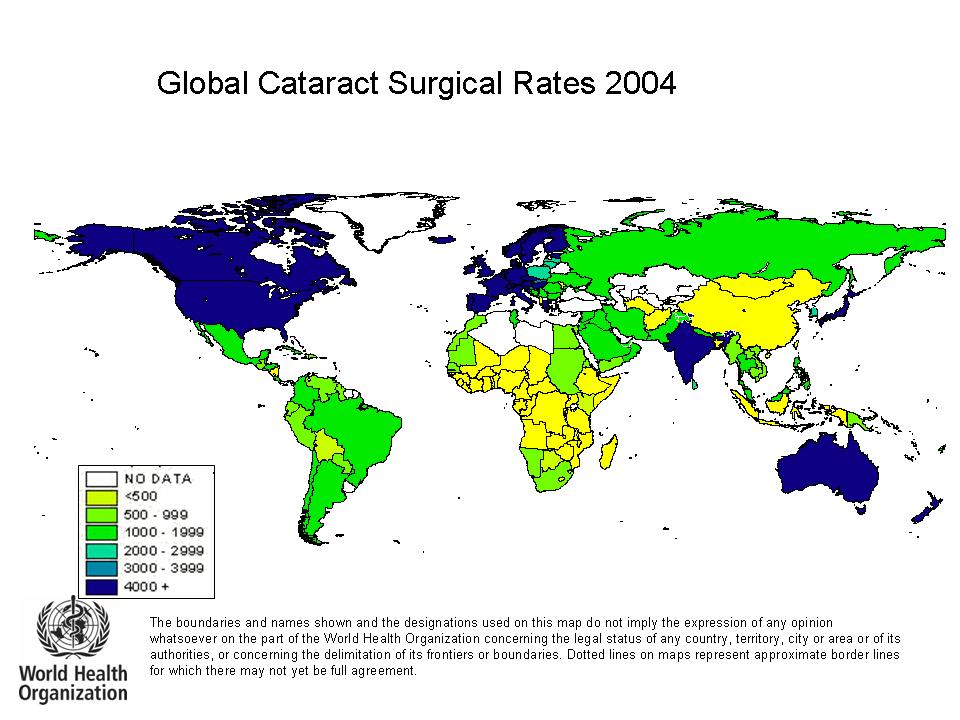
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Figure 1.1: Worldwide Surgical Rates for Cataract [1].

A cataract is a clouding of the lens inside the eye which leads to a decrease in vision. It is the most common cause of blindness worldwide and is conventionally treated with surgery [2]. According to the report published in 1998 by The World Health Report, there are estimated 19.34 million people who are bilaterally blind from age-related cataract [3]. This represented 43% of all the blindness.

According to the WHO, the cataract is the leading cause of blindness and visual impairment in the world [4].

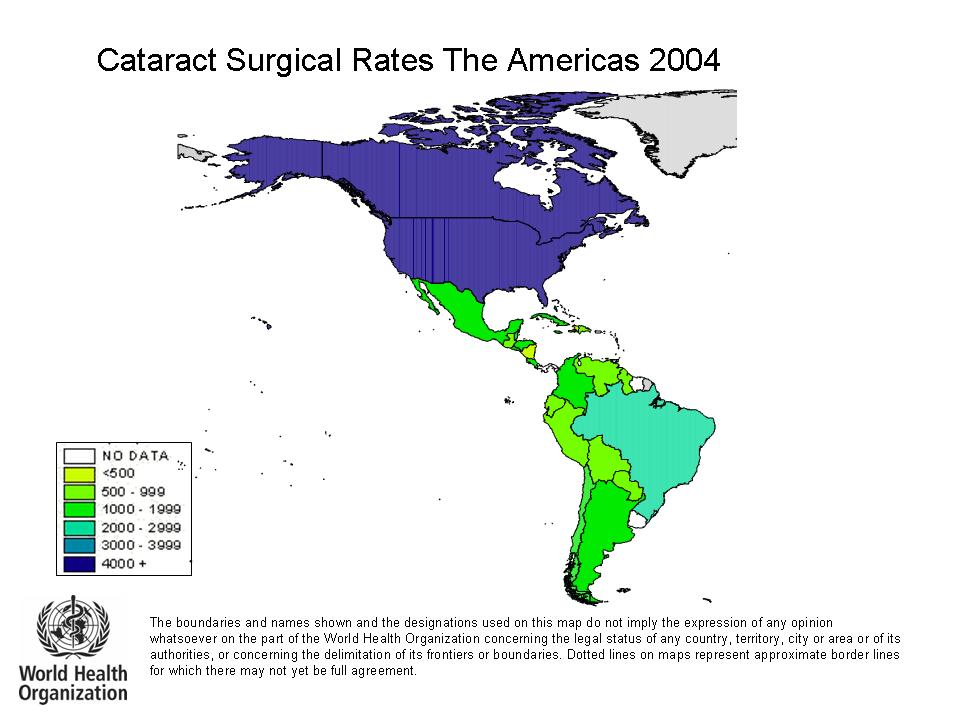
.

Figure 1.2: Surgical Rates of Cataract in USA [5].

In America, there are almost 22 million people of ages 40 and older suffer from cataract. In their 80’s, more than half of Americans have cataract. The estimated costs for the treatment of cataract annually are around 6.8 billion USD [6]. The doctor to patient ratio is very low. For example the number of ophthalmologists in USA are 18,305 and those all over the world are approximately 200,000 [7].

Anemia is a condition defined as the decrease in the amount of red blood cells or hemoglobin in the blood. It can also be defined as the ability of the blood to carry oxygen [8].

Usually, Anemia is diagnosed by invasive methods, such as filter paper method, copper sulfate method. All these methods involve extraction of blood from the body.



Figure 1.3 Extracting Blood for checking hemoglobin [9]

The unbalance doctor to patient ratio and the invasive techniques used to diagnose both these diseases persuaded us to come forward with an application that would be able to diagnose these two diseases using noninvasive methods.

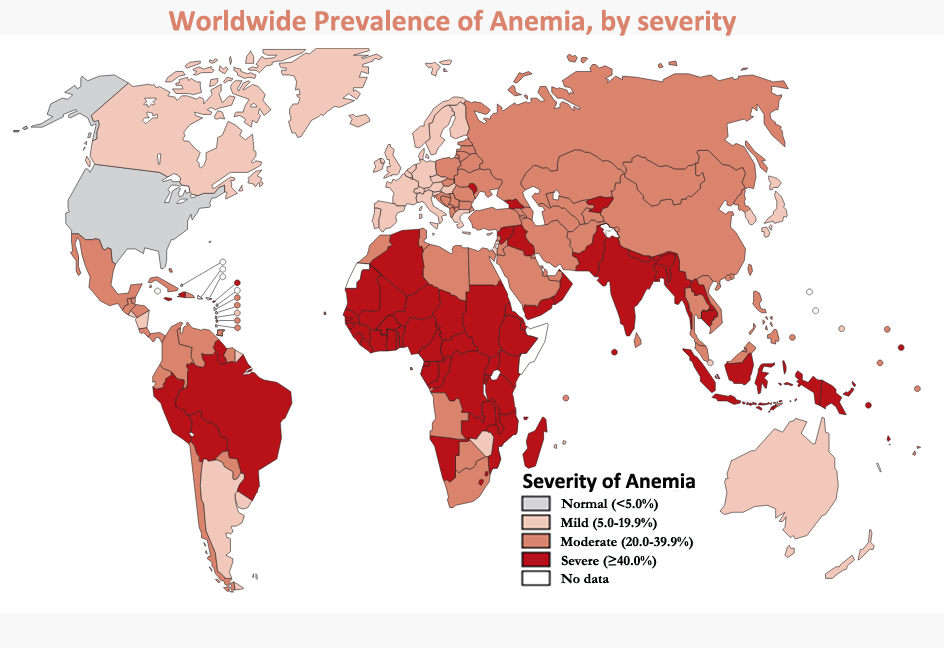


Figure 1.4 Estimation of anemia prevalence by vulnerable group and region [10]

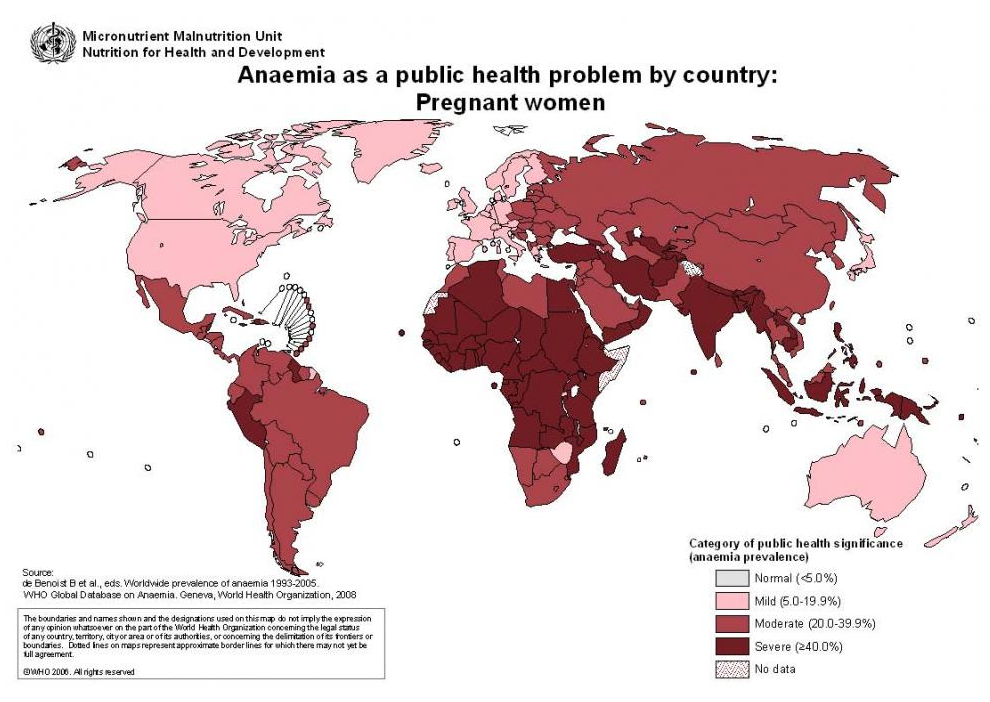


Figure 1.5: Worldwide statistics of Anemia [11]

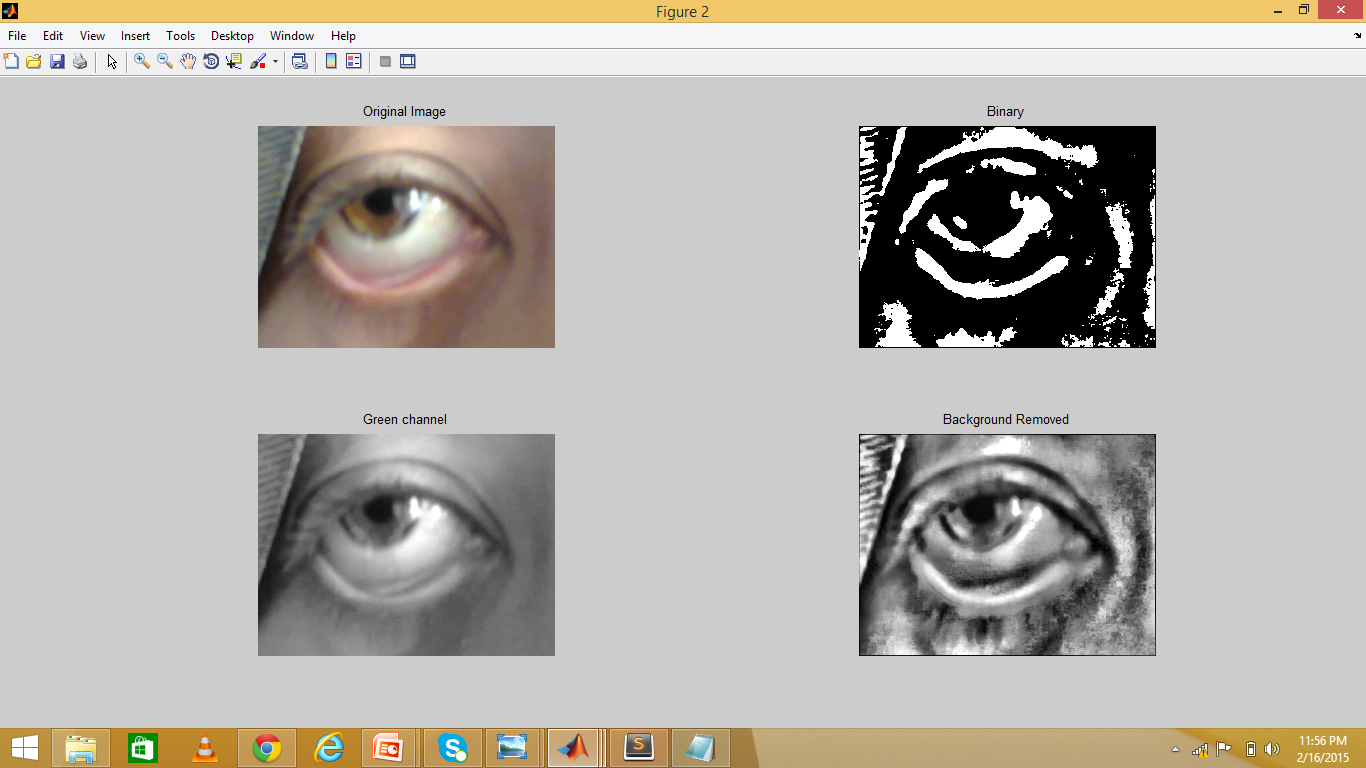
**Scope**

Our project is a mobile application that enables the users to be able to diagnose cataract and anemia by using a mobile camera. The diagnosis involves acquiring an image of the subject’s eye and running it through an algorithm developed using the techniques and concepts of image processing and then classifying the image as normal or abnormal using classification through texture analysis. The overall system is based on a mobile phone and a host machine which would communicate with each other

**Overall System**

**Anemia**

The overall system of the identification of Anemia is shown in Figure 1.6. The main steps of the procedure is as follows:

CLAHE (Clip Limit Adaptive Histogram Equalization)

***Pre-Processing***

* Red channel Extraction
* Image Intensity Adjustment
* Median Filtering
* Averaging Filter
* Gaussian Filter

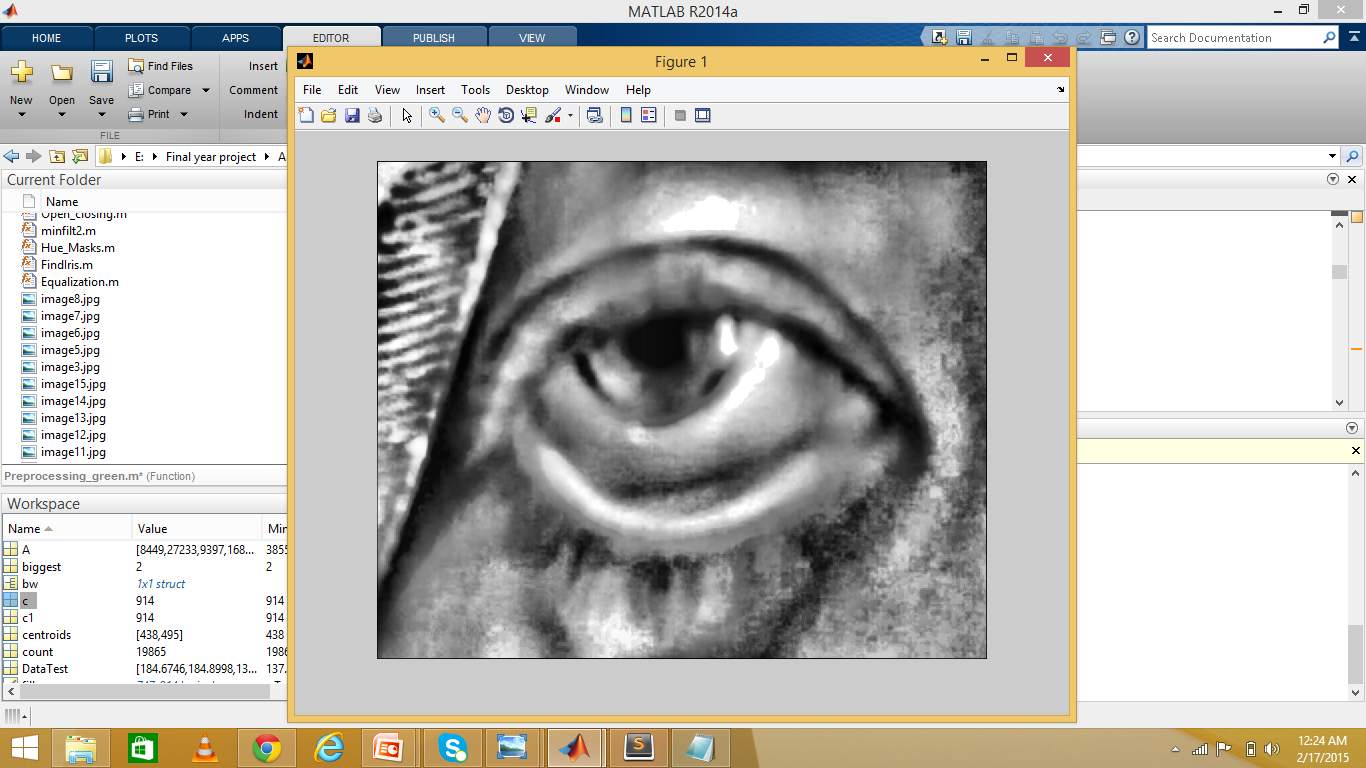
 

Image Translated Dilation + boundary masking with upper boundary of size R/3+Object Selection Based On Largest Area

Thresholding

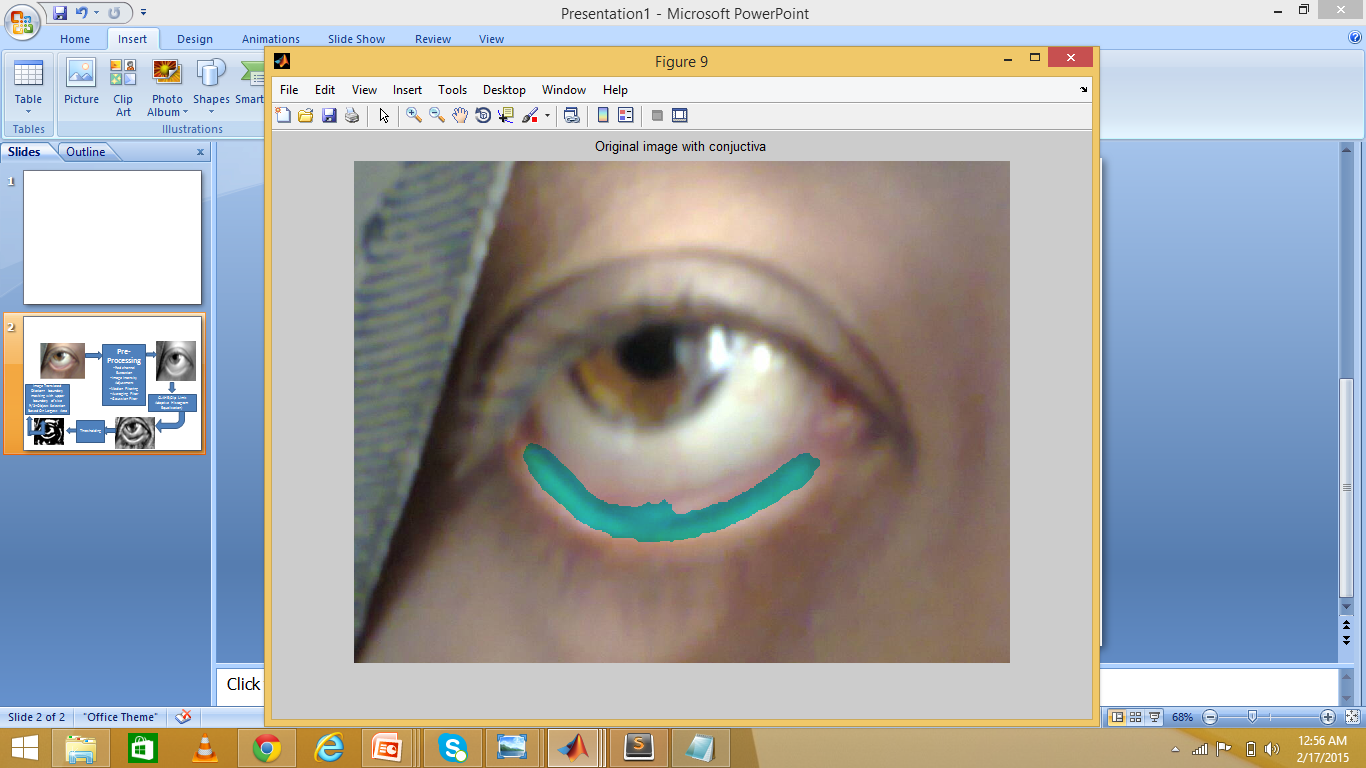


Figure 1.6

The process includes preprocessing of the image taken of the eye. The preprocessing includes the red channel extraction and then the image intensity adjustment. Median and averaging filter is applied on the resulting image and Gaussian filter is applied on it. After the preprocessing clip limit adaptive histogram equalization is applied on the image and thresh holding and the image translated and boundary masking with upper boundary of size R/3+Object Selection Based On Largest Area.

**Cataract**

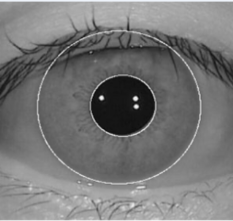
The overall system that detects the cataract is shown in Figure 1.7. The main steps are listed below:

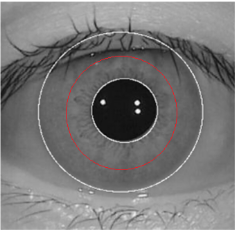
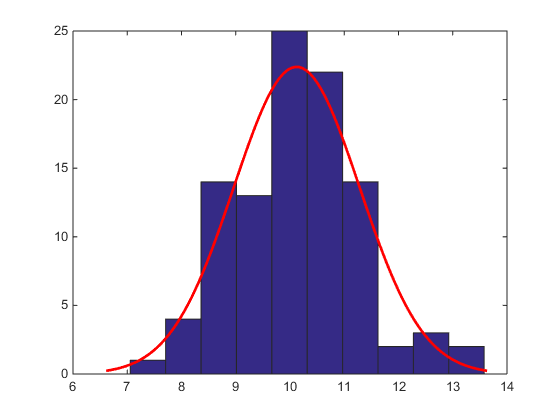
Processing for iris/pupil localization

Localized Iris/Pupil

Cropped Image

Image Acquisition





Texture Analysis

Classification

Intensity Normalization

ROI around Pupil

Figure1.7: Flow of work for the localization of Iris/Pupil

* Acquiring the image of the subject
* Cropping the image to avoid other details of the face
* Running the image through iris/pupil localization algorithm to detect iris and pupil
* Figuring out the Region Of Interest
* Using texture analysis techniques to classify between normal and abnormal images

**Structure of Thesis**

This thesis introduces the diseases that are under consideration. Then it explores their statistics, causes and their types. In the next part, this thesis explains the pervious methods that were proposed to detect/diagnose these diseases. Our methodology comes next. We have explained the method adopted by us and the algorithm developed in detail covering every little detail. Finally we come to the conclusion and the future work that can be done to further expand our project or to further improve the methodology and any shortcoming that may have remained.

**Chapter Two**

**Anemia & Cataract**

**2.1 Anemia**

Anemia is a disease which is caused mainly by the deficiency of red blood cells or deficiency of hemoglobin in the blood resulting in pale appearance of the patient and weariness. Hemoglobin is actually the primary portion of red blood cells and bind Oxygen. Having a very few red blood cells or if the hemoglobin level is low in the body, the cells don’t get enough amount of oxygen. Anemia is one of the most common blood conditions which is affecting a large number of patients around the globe. Anemia is caused because of one or more processes briefed as follows:

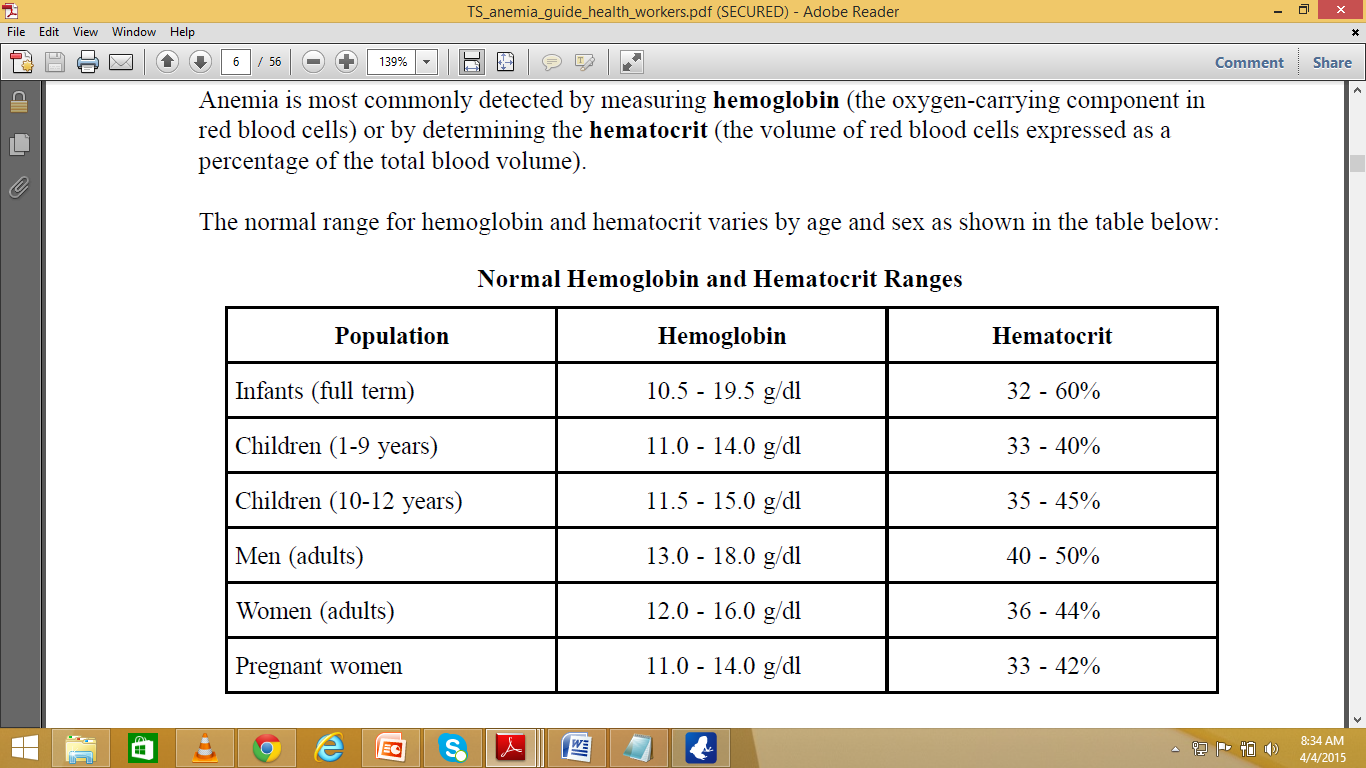
* Defectiveness in the formation of red blood cells because of diet lacking essential nutrients, deficiency of iron, or increased utilization of nutrients such as during pregnancy, lactation, or rapid menstrual cycles.
* Rapid number of red cell destruction because of parasitic conditions like malaria or sickle cell anemia (genetic condition) or thalassemia.
* Blood loss which is because of hookworm of large menstrual flow.

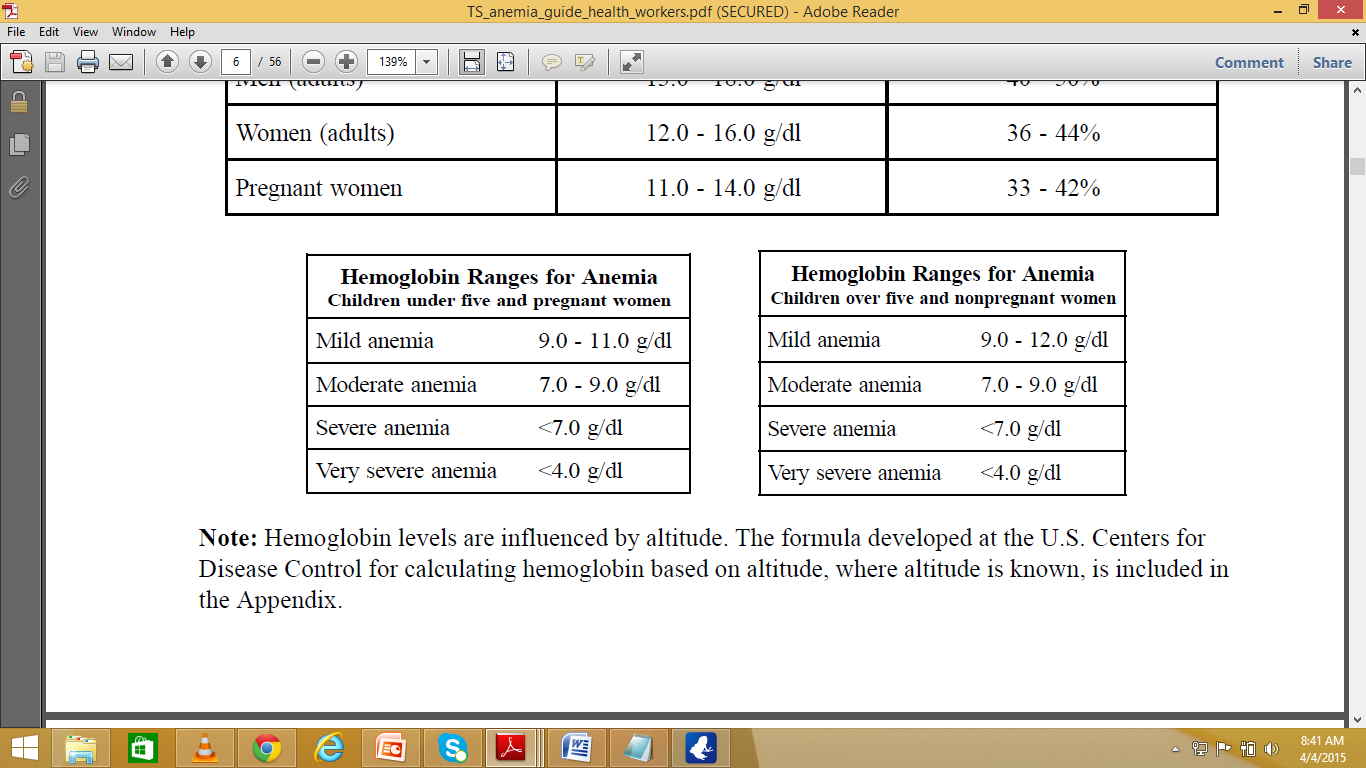
The common way to depict the state of Anemia is by measuring the hemoglobin of the patient. (Oxygen carrying component in red blood cells) or by estimating the hematocrit.

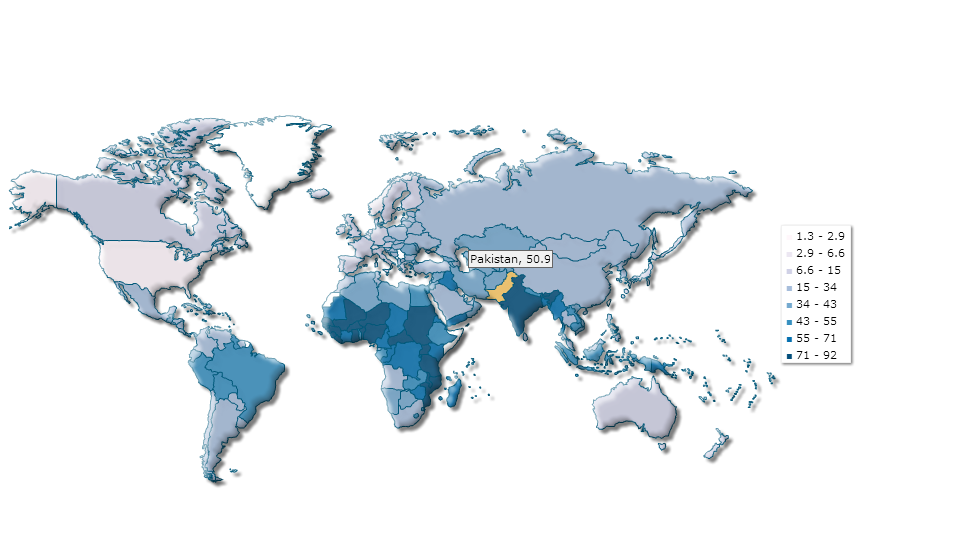
Following are some of the types of Anemia:

* Iron Deficiency anemia
* Thalassemia
* Aplastic Anemia
* Hemolytic Anemia
* Sickle Cell Anemia
* Pernicious Anemia
* Fanconi Anemia

The most commonly found type of anemia is Iron Deficiency Anemia. The normal range of Hemoglobin is:

Figure: 2.1 Normal Hemoglobin and Hematocrit Ranges

Figure: 2.2 Hemoglobin ranges for Anemia of pregnant, non-pregnant women and children

****

# Figure: 2.3 Prevalence of Anemia among children (percentage of children under 5) [12]

**2.1.1 Invasive Methods of measuring Hemoglobin:**

Some of the methods of measuring hemoglobin values from blood samples are as follows:

**2.1.1.1 Filter Paper Method:**

Red color in the blood can be illustrator as a pointer of the hemoglobin present in the body. Degree of Anemia can be visualized by matching the color of the blood on the filter paper with the standardized color chart. The color chart has been developed to represent the color range of normal to anemic blood on filter paper.

**2.1.1.2 Copper Sulfate Method:**

### The specific gravity of blood is influenced by red blood cell volume. The copper sulfate test is based on the fall (or flotation) of whole blood when dropped into a copper sulfate solution of a known specific gravity. The drop of blood will either float or sink depending on whether it is lighter or heavier than the copper sulfate solution. Standard copper sulfate solutions are used to determine a particular hemoglobin level [13].

**2.1.1.3 Hematocrit by Centrifuge:**

The hematocrit level, or packed cell volume, is a measure of the ratio of the volume of red cells to the total volume of whole blood (plasma, white blood cells, and red blood cells) and is expressed as a percentage. The ratio is determined after centrifugation. The hematocrit level is approximately 3 times the hemoglobin level [14].

**2.1.1.4 Lovibond type Comparator:**

The Lovibond visual color comparison method is based on comparing the depth of color that results when an accurate measurement of blood is added to a diluting fluid with a set of colored glass standards. The hemoglobin in the blood is converted to oxy-hemoglobin or hemoglobin cyanide depending on which diluting fluid is used. The color of the test solution is visually compared with a set of glass standards set in a disc that match the diluted hemoglobin fluid. The intensity of color in the test solution corresponds to a specific hemoglobin level. [15]

**2.1.1.5 Statistics**

Almost one quarter of the world’s population is anemic. The major divisions which are most at risk of developinganemia include women which are of reproductive age (affected due to menstruation), pregnant women, lactatingwomen and children of the age varying from 6 months to 2 years. Almost one half of the total pregnant women in the world are anemic. In developing countries the ratio is between 55 to 60 percent whereas 18 percent are women are affected in developed countries. Anemia is a fatal disease affecting nearly 1 billion people in the world. In 2013, anemia due to iron deficiency resulted in almost 183,000 deaths.

**2.2 Cataract**

According to the World Health Organization (WHO), “Cataract is clouding of the lens of the eye which impedes the passage of light. Although most cases of cataract are related to the ageing process, occasionally children can be born with condition, or a cataract may develop after an eye injury, inflammation, and some other eye diseases” [15]. Cataract scatters the light that passes through the lens rendering the image to be blurred or clouded. Cataract remains the leading cause for blindness.

**Major Causes of Cataract**

* **Ageing:** The main factor for cataract is ageing which is inevitable. The number of people that have cataract will eventually increase as the world population ages. Some statistics show that the 400 million people of aged 60 or less would double to at least 800 million in 2020. This population increase will increase the number of people having a chance of cataract.
* **Trauma:** Any kind of injury to the eye, blunt trauma that causes the eyes to swell can induce cataract in the later stages. The blow can cause swelling, thickening and whitening of the lens. The swelling can heal with time but the white color remains. Other injuries that penetrate the eyes can damage the place where the lens rests, allowing the water to swell and whiten the lens. This obstructs light to go to the retina.
* **Ultraviolet Light:** Ultraviolet radiation and Microwave radiation can cause cataract though the mechanism is unclear till today but there are theories presents that suggests the link of cataracts to radiation exposure.

One theory suggests that the radiation causes the heat sensitive enzymes that protect the proteins in the lens. Other suggests that the damage dealt to the lens with direct exposure to pressure waves induced in the aqueous humor

* **Genetics:** Genes can be a major component in the formation of cataracts.
* **Smoking:** Smoking causes the rate of having nuclear cataract and triples the rate of posterior cataract.
* **Medication:** Some drugs used as medicines can contribute to the development of cataracts like steroids and other medications taken to control the diabetes [16].

**2.2.1 Types of Cataracts**

* **Nuclear Sclerotic Cataract:**  The major cause of cataracts is the ageing problem that hardens the lens and makes it yellowish over time as you grow older. The “Nuclear” refers to the central portion of the lens which gets clouded and yellowish. “Sclerotic” refers to the hardening of sclerosis of the lens nucleus. This type of cataract weakens the ability to focus. (Are there different types of Cataracts? By Tina D. Turner, M.D., Vision Aware, Resources for Independent Living with Vision Loss [17]
* **Cortical:** This type of cataract refers to the whitening of the lens that causes opacity in the cortex region of the lens located outside the lens. It starts as whitish wedge shaped opacities that streak out to the edge of the lens cortex eventually the streaks extend to the center of the lens making the sight blurry. [19]
* **Posterior Sub capsular:** This type of cataract usually starts from the back of the lens hence the word “Posterior” in its type. The sub capsular is for the capsule on which the lens resides. It starts from beneath the capsule. These types of cataracts cause reading problems and tend to produce glare around lightening illuminated things. These are caused by the excessive use of drugs like steroids, or have diabetes and nearsightedness [20]

**Statistics**

* In India alone, almost 3.8 million people become blind each year from cataract [21]
* Despite the fact that the cataract removal surgery is considered as most efficien, safe and cost-effective intervention, people in rural and remote areas become blind due to little or no knowledge of cataract. The percentage of blindness due to cataract among all eye diseases is 5% in developed areas whereas this figure rises up to 50% for rural areas [22].
* Current population of 20 million people with a severely reduced vision of 3/60 or worse due to different types of cataract would be increased to 40 million by the year 2020 as the world population will increase by one third and during this period the population of the people of age 60 or elder will increase by more than double [23].
* An estimated 3.1% of deaths worldwide are directly or indirectly due to cataract, glaucoma, trachoma and onchocerciasis [24]
* Around 50% of blindness in sub-Saharan Africa is due to cataract [25]
* Globally, at least 100 million eyes have visual acuity <6/60 due to cataract [26]
* Globally, the need for cataract operations is at least 30 million per year, but only around 10 million cataract operations are performed annually [27]

**2.2.2 Overview**

Cataract is an eye disease. It forms a clouding on the lens in the eye. The proposed system uses the techniques of image processing and classification algorithms for the detection of diseases. For the detection of cataract we first need to isolate the lens of the eye for further processing. To isolate the lens, a localization algorithm is applied. This helps to separate the iris and the pupil of the eye. Simple cropping operation is then applied to obtain the Region of Interest (ROI) to extract desired features from the image. The processing involves the texture analysis by extracting features from the isolated image obtained. These features are then analyzed and a model is obtained which helps in deciding whether any given image of a lens has cataract or not.

Further details of the processes are explained below

John Daugman IEEE Transactions on circuit and systems for video technology, VOL. 14, NO. 1, January 2004) the pupil radius can range from 0.1 to 0.8 of the iris radius. A 10x10 window around the iris center searches for the pupil boundary using the daugman’s operator. Once the iris and pupil are extracted from the rest of the image of the eye, we can now extract the ROI from it.

**Chapter Three**  
**Background & Overview**

**3.1 Anemia**

**3.1.1 Literature Review**

Suner *et al.* proposed a way to non-invasively determine the hemoglobin level by taking a digital photograph of Palpebral conjunctiva. He used two arm process named as derivative and evaluation. In the derivation arm of the process he enrolled 44 patients to derive the formula for hemoglobin measurement. Hemoglobin in blood was already calculated using a cell counter. Then he developed a software to predict the hemoglobin values based on the formula derived using the known hemoglobin values and images from a derivation set of the process. He used the Pearson rank order correlation to see the correlation present between the calculated and measured hemoglobin levels. He first manually selected the conjunctiva region and cropped it. That cropped image was then separated into red, green and blue colored channels. Each image was represented by 16 million colors as 256 shades of gray in red, green, and blue component Images (256 \* 256 \* 256 = 16.7 million). Each pixel was assigned three values between 0 and 255, one for each color layer (0 = black, 255 =white, i.e., [145, 237, 12]).Next a formula utilizing the pixel values from the conjunctiva and standard and constant values were determined by an iterative process to optimize the predicted hemoglobin by comparing the results to known hemoglobin values and repeating the calculation after varying the constants. After the optimal formula was constructed, the process was applied to images prospectively to estimate hemoglobin.

**3.2 Cataract**

**3.2.1 Literature Review**

There are a number of methods that have been proposed for the automatic diagnosis of cataract a summary of some is given in the next few paragraphs.

Huiqi *et al*. applied his approach of “Image Based Diagnosis of Cortical Cataract” on 611 test images on which an accuracy of 98.2% was achieved. For the 466 images tested in the process, a mean error of opacity area detection was 3.15% compared with a human grader and 85.6% of exact cortical cataract was obtained. The proposed system first determined the Region of Interest (Detection of Pupil). The cortical opacity was detected by employing the spoke feature to separate from other opacities such as PSC. At first the image was converted into its polar coordinates then local thresh holding and edge detection was applied both in radial and angular direction to detect opacity centers and opacity edges respectively. Both the results were merged and were reverted to Cartesian plot. Angular opacity was subtracted from radial opacity to retain only the cortical opacities as cortical seeds.

Jagadish Nayak presented a method of automated classification of normal, cataract and post cataract optical eye images using SVM classifier. A total of 174 images, roughly of all age groups (male and female), were acquired from Kasturba Medical College, Manipal, India. The images were of size 128x128 pixel. Small Ring Area and Big Ring Area were calculated next and then edge detection was used to compute the EPC 9Edge Pixel Count). The approach used for the detection was based on the fact that in the images having cataract, there are many sudden changes in gray levels hence there are many edges. Erosion was applied with a 3x3 structuring element with all ones. SVM classifier was applied with 4 features i.e. Small Ring Area, Big Ring Area, Edge Pixel Count and Perimeter. A sensitivity of 94% and a specificity of 93.75% was achieved

A method of extracting information from the pupil of the eye for the detection of cataract was proposed by Retno *et al*.using specular reflection analysis. The features were extracted using the specular reflection analysis and statistical texture that consists uniformity and average intensity for handling problems. Support Vector Machine classifier was used to classify the image based on the features that are listed above. The system was tested on 217 images. 137 of the images were declared as serious condition by the eye diagnosis doctor and the other 80 were non-serious. The percentage values of the images declared as True Positive by the proposed system were 91.97% and the percentage of False Positive were 18.75%.

A method for improving cataract screening techniques was proposed by Retno *et al*.

The method proposed first localized the Iris to get the Region of Interest. Six features were extracted namely Average Intensity, Average Contrast, Smoothness, Third Moment, Uniformity and Entropy. The tested data was obtained from Kamandaka Eye Clinic, Indonesia.

In another system proposed by retno *et al.,* the system first localized the pupil region of the eye and the looked for the front and backside reflection on the lens. Then cataract was diagnosed by developing a differential equation model that provided a screen between the normal and serious condition.

**CHAPTER FOUR**

**Research Methodology of Anemia**

**4.1.2 Methodology**

Systems based on image processing and machine learning plays a vital role in Computer

Aided Diagnostic systems. CAD based systems has set new ways to detect various diseases. Similarly CAD based systems are very useful in detecting Anemia. A disease in which there is a deficiency of red blood cells. Figure 1 shows the complete setup of the proposed system from localizing a window for the detection of conjunctival pallor to the classification of the image as to what degree of anemia it has.

Our proposed system works on the techniques of image processing and machine learning and is divided into several steps. Image Input and its preprocessing, ROI (Region of interest) detection and classification based on certain features extracted from the ROI.

**4.1.2.1 Preprocessing:**

First input image is acquired and its green channel is extracted out. Then averaging filter with a window size of 5\*5 is applied on it to remove noise and smoothen the image further a Gaussian filter is applied to remove the noise and then a median filter is applied on the image to remove the noise due to dust on the camera lens.

**4.1.2.2 Region of Interest:**

As is visible from the image that the palpberal conjunctiva has great intensity variation than the other parts of the image. Here Normal Histogram Equalization is not useful because it gives only global contrast enhancement. The other disadvantage of using this is the noise present in the background of the image. To overcome this Adaptive histogram Equalization (AHE) was used which takes each pixel from the input image and transforms the intensity according to contextual regions. AHE besides this also enhances noise contrast in areas where there is homogeneous regions which produces unwanted and unnatural effects. So now in order to segment out the ROI from the image CLAHE is applied. CLAHE works in such a way that it partitions the image into contextual regions and then it applies the histogram equalization to each partitioned region after removing noise from the background of the green channel. This process evens out the grey value distribution and in result makes the hidden features of the image more visible and contrast enhanced. We have used Exponential distribution function [16] to obtain the high contrast for the palpberal Conjunctiva.

**G=gmin-(1/a) \*ln[1-p(f)] (1)**

After applying CLAHE, Otsu’s method is one of the best algorithm to binaries the image. Otsu’s method is used to automatically perform clustering based image thresholding. Otsu’s method search for threshold that minimizes intra class variance threshold, which is defined as the weighted sum of variances of two classes. [17]

**w=tt (t)** **(2)**

**Where =** Probabilitiesof the two classes which are partitioned by threshold t and ****is the variance of the two classes.

Here the class probability w1 is computed from the histogram till t: [17]

**t=Σ0tp(t) (3)**

And the class mean is given by: [17]

**1=Σ0tp(i)x(i) /w1 (4)**

Here x(i) is center value of the ith histogram bin. Similarly histogram bins of the other site can also be calculated.

This process threshold the image to give the binary mask of the Conjunctiva and some other noisy data which needs to be removed. The binary image thus obtained contains certain imperfection due to noise and texture that needs to considered first for further processing of the mask. After Thresholding first Morphological dilation is applied on the image in order to remove any breaks in the Conjunctiva region. The dilation of an image say *f* by a structuring element say *S* produces a new binary image given by equation 5.[18]

**G=*f https://www.cs.auckland.ac.nz/courses/compsci773s1c/lectures/ImageProcessing-html/sign-dilation.gif S* (5)**

Now this morphological dilation would result in a new image G with ones in all location the structuring element hits the image *f* i.e. G(x)=1 if s hits f and 0 otherwise.

This morphological Dilation results in an image with improved boundaries and if there are any breaks in the conjunctiva region than it also combines it and produces whole binary mask of the conjunctiva. Now this dilated image have conjunctiva region along with some noisy binary object in order to remove the boundary noise a binary mask with upper boundary of size R/3 is formed and applied on the image which result in an image that has less noise. After that area of each binary object in an image is calculated and the image with largest area is taken out as the conjunctiva region. Further to take a window out of this conjunctiva centroid pixel of the conjunctiva is calculated and using that centroid pixel some pixels from all sites of centroid are taken to create an exact window over the conjunctiva region.

**4.1.2.3 Classification:**

The ROI segmented from the image contains information about the presence or absence of anemia by measuring the level of hemoglobin from it. So in order to classify ROI into different levels of Anemia we have used support vector machine.

**4.1.2.4 Feature set Formulation:**

The ROI segmented from the image is taken as a candidate for classification of anemia. This ROI represents a sample region of the conjunctiva having features used for classification of anemia. Now let’s take this ROI and represent it by x from an image Y and let’s suppose this region contains z number of features then the feature vector for the given ROI is given by x={Y1,Y2,Y3,…, Yz}. We have extracted following features and their brief description is given below.

1. **Mean of RGB:**

Mean of R, G and B channels are calculated separately for each channel and are used for the **classification of Anemia.**

1. **Mean of HSI:**

HSI refers to the color space that correspond to a better experience on how people see color than RGB color space. Hue channel varies from zero to 1 when color varies from red to green and then to blue and black to red. Here S represents the amount of white color mixed with monochromatic color. Mean of H (hue), S (saturation), I (Intensity) are calculated separately for each channel.

**3. Standard Deviation of RGB:**

Standard Deviation represents the deviation of the RGB channels separately from their mean values.

**4. Standard Deviation of HSI:**

Similarly this represents the standard deviation of the HIS channels separately from their mean values.

**4.1.2.5 Support Vector Machine:**

The support vector machine is used to classify different level of hemoglobin. The feature vector containing all the features is fed to svm and it then automatically grade the image according to two classes. Originally SVM algorithm separates different regions from one another with maximum margin using a separating hyper plane if and only if the classes are linearly separable. Now let’s say that for a linearly separable data labeled as xi, yi where

xiRMd , yi={1,-1} and i=1,….,M hyper plane can be represented by w and b such that

**yi(w.xi+b) > 0 (6)**

Where yi is the class of ithfeature vector xi. So now all samples with y=1 lies on one side of the plane and samples with y=-1 lies on the other side of hyper plane. Two planes have been generated using w and b that are separated from each other and no point lies in between them. The distance between these two hyper planes is defined by

**Margin=2/[W] (7)**

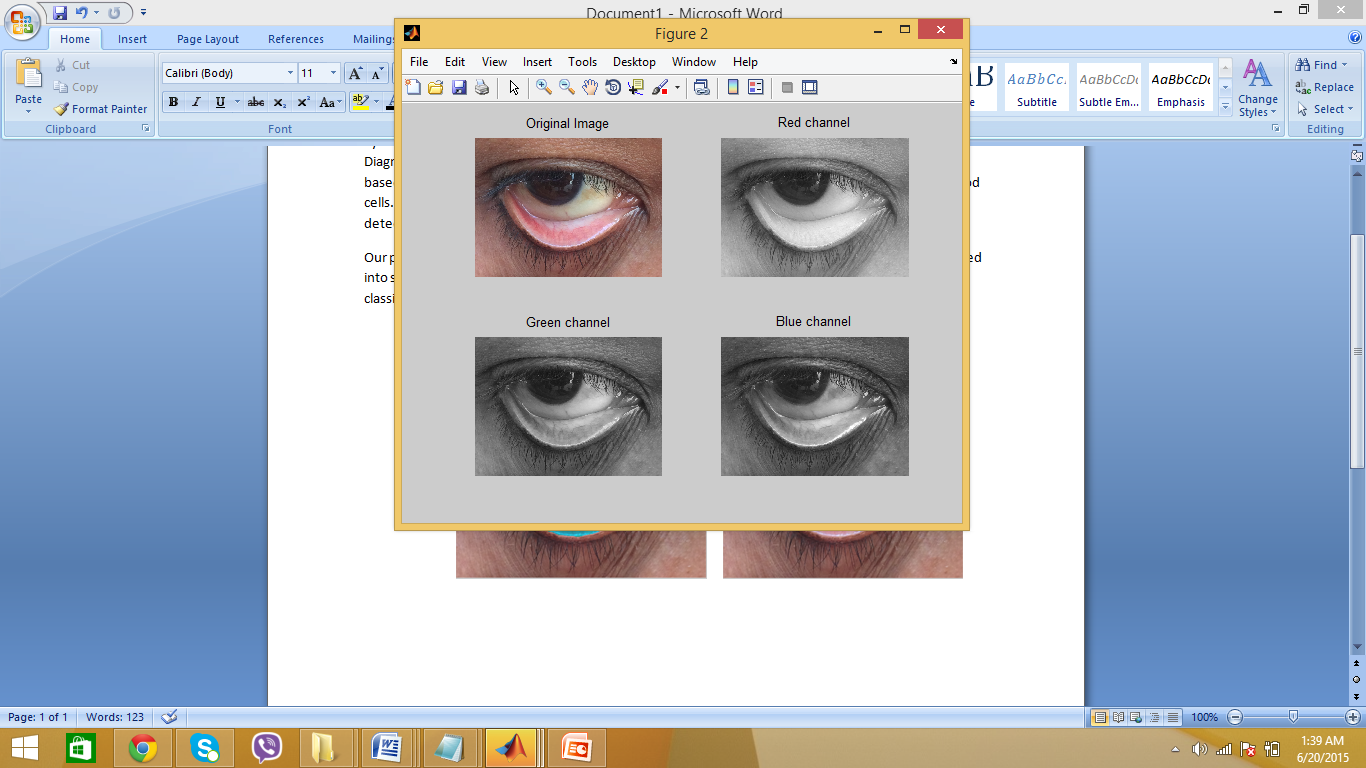
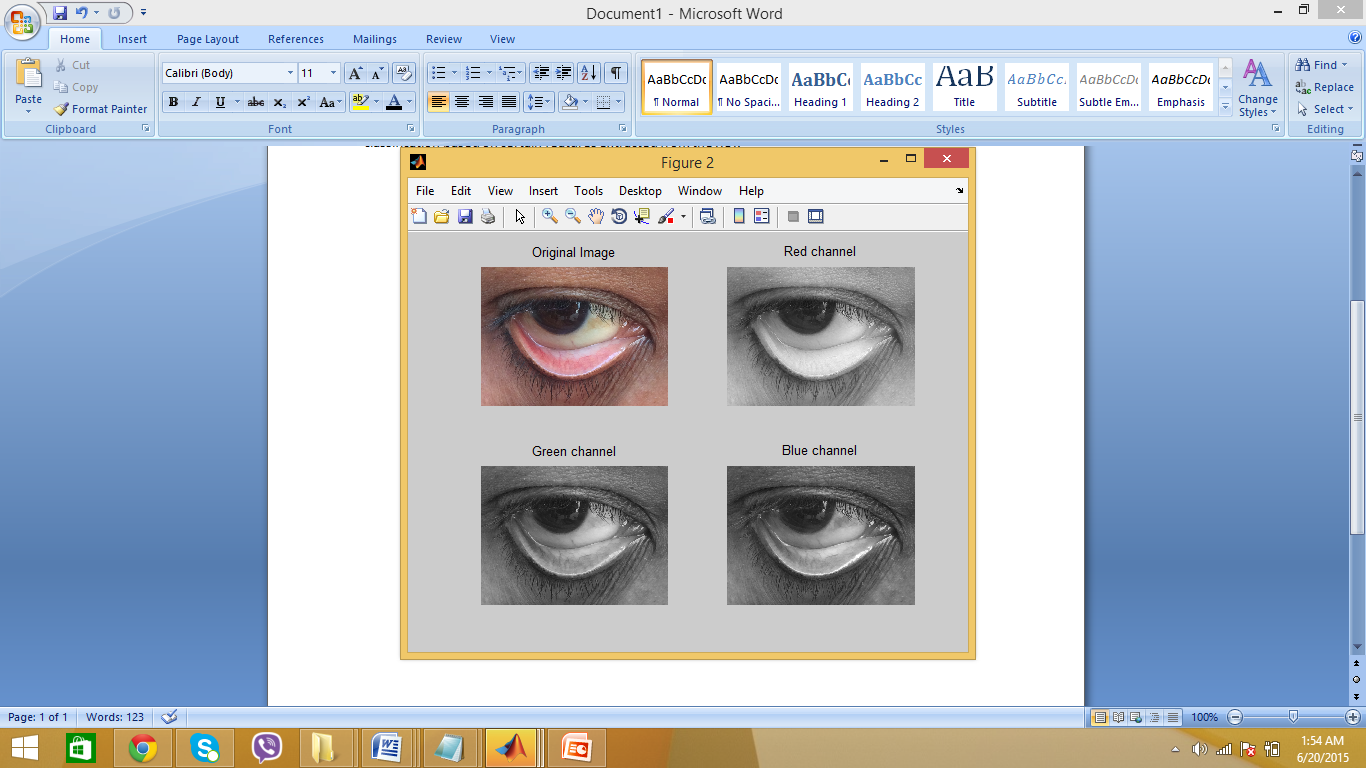
Looking at the above equation one can increase the margin between two hyper planes by minimizing w. One thing to look at is that there shouldn’t be any samples between the planes so altering equation 6 into equation 8

**yi(w.xi+b) >=1 (8)**

Here a problem occurs with equation 8 that the dimensions of xmakes the optimization of w much difficult and a solution to it can be found in langrangian multipliers i­such that the w=ΣNi=1 iyixi andΣNi=1 iyi=0.Now w and I have direct correspondonce. So now the contributing samples in determining hyper plane should have non zero i. These samples are known to be support vectors and the decision rule can be given by

**y(v)=sign[ΣNi=1iyiK(v , xi)+b)] (9)**

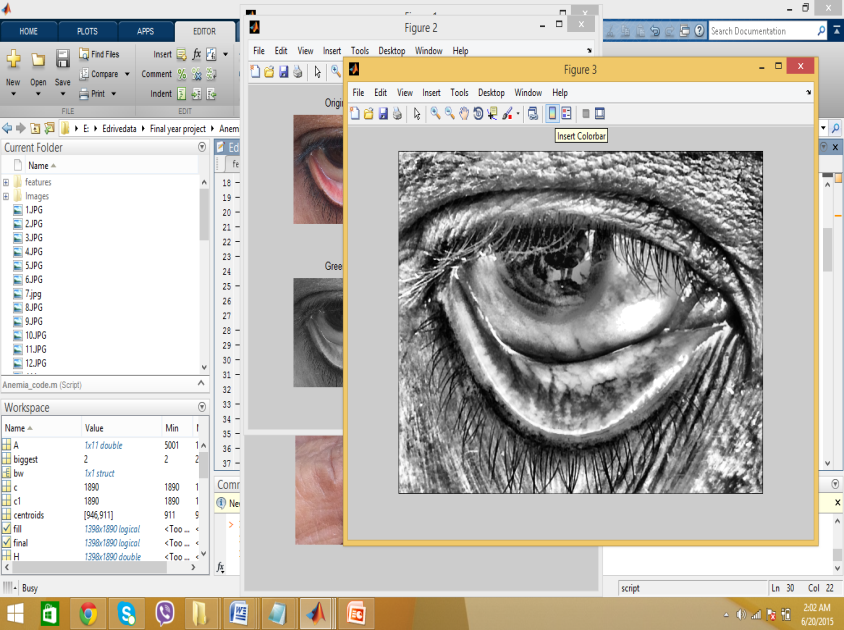
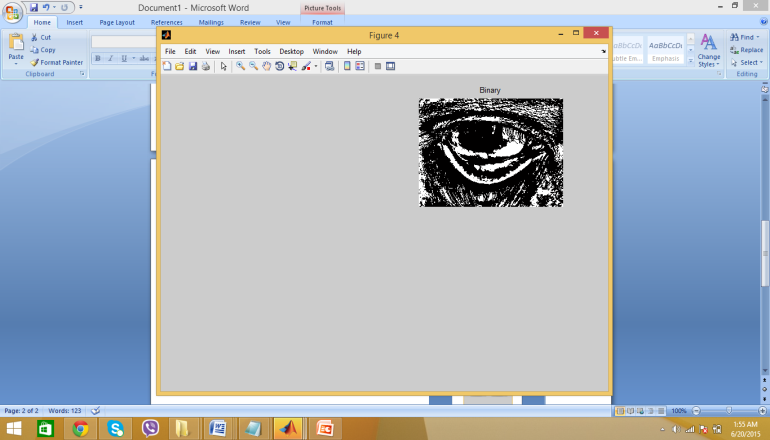
where K(v,xi)= Kernel function.



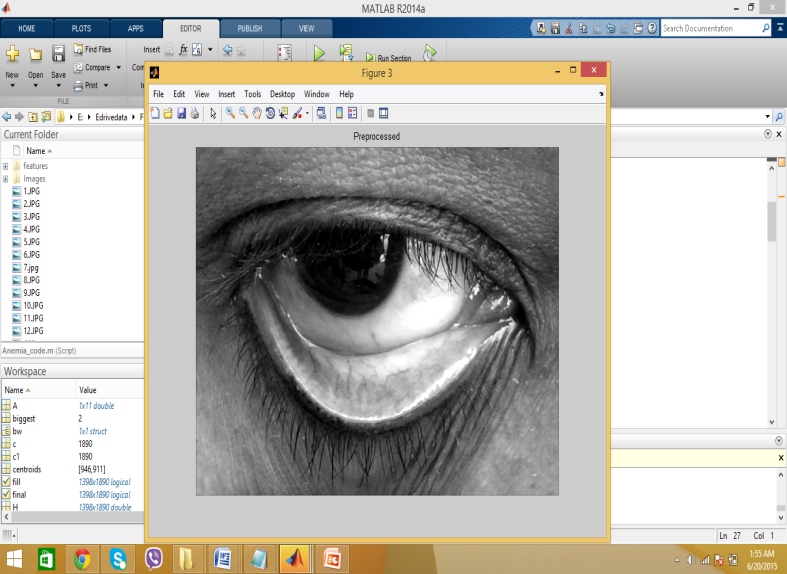
Preprocessing:

* Averaging Filter
* Image Intensity Adjustment
* Median Filter
* Gaussian Filter

Green Channel Extraction

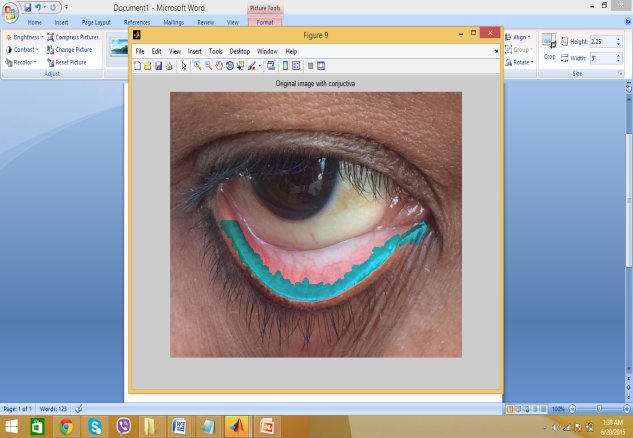
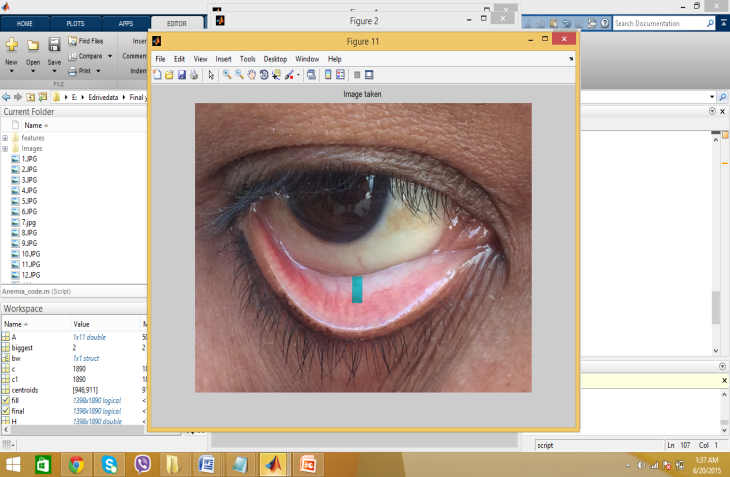


Thresholding using Otsu’s Method



CLAHEE

Image Translated Dilation+ boundary masking with upper boundary of size R/3+Object Selection Based On Largest Area



ROI selection using a centroid pixel of the conjunctiva

**Feature Extraction:**

* Mean RGB
* Standard Dev. RGB
* Mean HIS
* Standard Dev. HSI

Hemoglobin classification of 8g/dl or 10g/dl.

SVM(Support Vector Machine)

Classifier

Figure 4.1: Proposed System for Anemia

**4.1.2.6 Experimental Result:**

The Evaluation of the proposed method is performed on a locally gathered dataset using iPhone 5s camera. The dataset consist of 28 images with resolution of 2248\*3226 having hemoglobin levels of 8 and 10 been manually graded by Medical Doctor.

**4.1.2.7 Results:**

The results of the proposed method are accurate up to 70%. And out of 28 images the conjunctival region of 25 images are correctly detected. The results of localizing the region from some of the image are shown in figure 2.

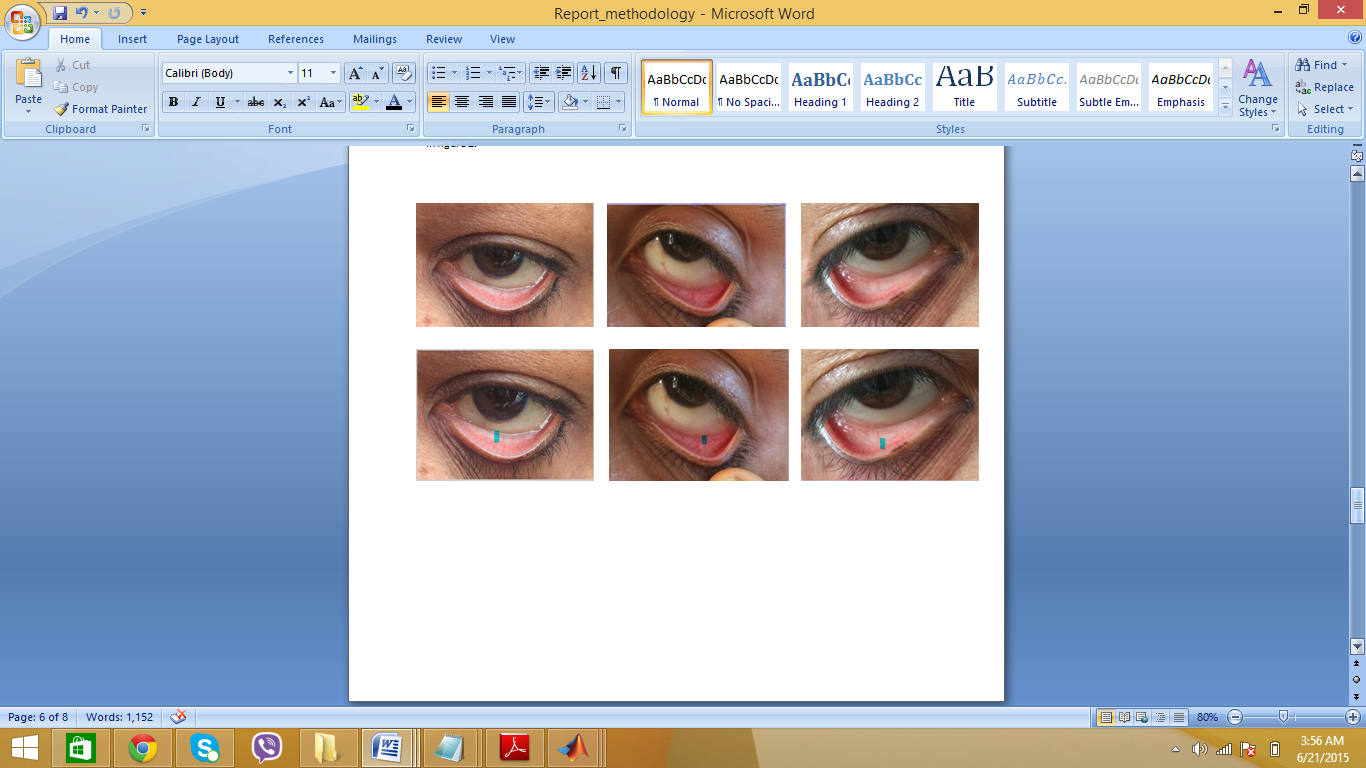


Figure 4.2: Upper Row Original Images. Lower row Image with ROI.

**Research Methodology of Cataract**

**4.2.3 Image Acquisition:**

The proposed system requires the user to take an image through the camera of his/her mobile phone. A standard smart phone camera is required for the image acquisition. The image should be taken in good light conditions. Precautions should be taken so that the image does not have reflection in the lens which hinders in the application’s accuracy to classify the image.

**4.2.4 Preprocessing:**

The image is then preprocessed to remove noise using filters. The images obtained are usually of higher quality which slows down the processing speeds. The image is scaled down so that its resolution becomes 640x480 pixels.

**4.2.5 Iris/Pupil Localization**

We are using a modified method of Camus & Wildes algorithm for iris detection to find the possible centers coordinates of iris and pupil along with their radii. The method involves thresholding to determine the possible coordinates that would correspond for the iris center in the local pixels (i.e. in a 3x3 window). Using the Daugman’s method for iris boundary detection we then search for the pupil boundary within the 10x10 neighborhood of the iris center.

**4.2.6 Daugman’s Integro Differential Operator**

The daugman’s integro differential operator is given as

max(r,y0,x0) [29]

This operator forms the bases for the iris and pupil localization. The above operator searches for maximum blurred partial derivative in the given x and y coordinates and iterates by increasing radius of the contour (i.e. r) with center coordinates x0 and y0 of the line integral present in the operator. The operator also includes the convolution with a Gaussian filter. Overall the operator looks for the circular boundary of the iris and pupil with its circular contour with increasing radius and returns the radius of the best possible radius and coordinates of the iris and pupil.

Our approach implements the daugman’s operator with a few additional operations to isolate the iris and pupil for ROI extraction. Below is the detailed explanation of the steps followed in the path of isolating the required elements from the image

**4.2.7 Thersholding**

The input image is scaled to a constant size to speed up the process. Morphological operations are applied to remove the reflections from the image. The image produced by the morphological operations is sharp; filter is applied to blur the sharpness of the image. Using thresholding, possible pixel coordinates are chosen for the center of iris. Then the neighborhood of those coordinates is scanned to see if it is the local minimum or not. We have an array of possible coordinates for the center of the iris. The blur of each coordinate is then calculated by applying the daugman’s operator. The search function then searches the maximum value of blur by scanning all the center coordinates.

* + 1. **Line Integral**

The normalized line integral is calculated around a circular contour. The polygon with large number of sides is used to make out a circle from the image and hence used to calculate line integral using summation. The line integral iterates form the minimum given value of radius to the maximum and taking in view all the possible center coordinates for iris and pupil. The line integral finds the circular boundary with the help of the contour with radius r and center points x0 and y0. The best possible value of radius of pupil and iris is obtained.

**4.2.9 Partial Derivative**

When the line integral finds the boundary that best fits the contour, which means a circle has been taken out of the image as the boundary of iris. Once the circle is taken out, the iteration stops and no more computations for calculating the line integral of the radius for that particular center are performed. Differential is calculated for the obtained line integral. A 1-D Gaussian filter of 5x5 structural elements with appropriate value of sigma is applied. The blur image is obtained. The partial derivative of blur is calculated.

**4.2.10 Searching**

The maximum value of blur is found by scanning all the possible center coordinates for iris. Once the iris boundary has been found, the algorithm then searches for the pupil boundary by searching only some part of the image. The part is in the neighborhood of the iris. As per Daugman [30] (How Iris Recognition Works by

**4.2.11 ROI Extraction**

The Region of Interest is the area outside the pupil but inside the iris boundary. So we take a simple square cropping window and crop out the area of interest that is within the boundary of the iris but includes the pupil region. This are obtained is the ROI required to perform further analysis for the detection of cataract.

**4.2.12 Classification**

After the iris and pupil have been localized, ROI extracted, we now extract information in terms of different properties of the image. These properties can be common in all cataract affected eye images therefore making a range of values that, when obtained in the run time, can help to identify cataract. These properties are called features and a group of them becomes a feature set matrix. This matrix helps us to model or train a classifier a Support Vector Machine (SVM) in this case. This classifier is trained with features of some training dataset including a few normal and a few abnormal images. More images we include in the training of the classifier, more accurate results can be expected.

**4.2.13 Feature Extraction**

Further information from the ROIs is obtained in the classification process. Each ROI of an image gives off 6 features. These features are considered similar for cataract and non-cataract images.

**4.2.14 Contrast**

Contrast can be defined simply as the difference between the maximum and minimum pixel intensity values in an image. Contrast of each ROI is calculated and treated as a separate feature. Contrasts of all images are stored corresponding to their images. [31]

**4.2.15 Homogeneity**

Measure of closeness of the distribution of the elements in the image. (Analyzing Texture of an Image, Matlab help, Mathworks Inc.)

**4.2.16 Correlation**

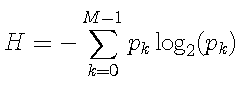
Measures the probability of occurrence of the specified pixel pairs in images ((Analyzing Texture of an Image, Matlab help, Mathworks Inc.)

**4.2.17 Energy**

It is simply the sum of the square of the pixel intensities in the image

**4.2.18 Entropy**

Entropy can be defined as the amount of disorder present in a system. When a system is disturbed its entropy changes. In an image when it has a normalized histogram, has a higher entropy value as compared to an image which is thresholded. If all the pixels of the image have the same value, its entropy is zero. Entropy of an image is given by the formula

 [32]

**4.2.19 Standard Deviation**

The standard deviation of the image the brightness within a region with some pixels is called sample standard deviation. The standard deviation is the estimate of the mean of underlying brightness of probability distribution. [33]

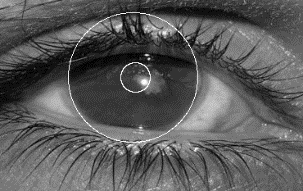
**4.2.20 SVM classifier**

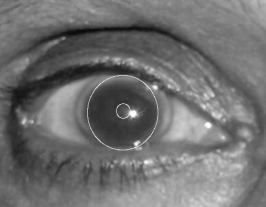
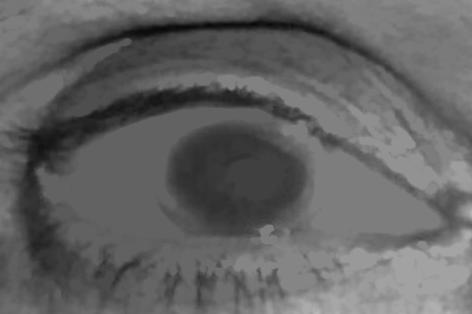
The classifier used for the detection of cataract is Support Vector Machine. It classifies the data into two classes. Either the image has cataract or it doesn’t. The feature set matrix is used to train the classification model. Basically, the SVM classifiers maximize the margin around the separating hyper plane. [34] The decision is supported by the subset of training samples; supporting vectors. These supporting vectors would change the position the hyper plane if they were removed so they are of high importance in the SVM classification modeling.

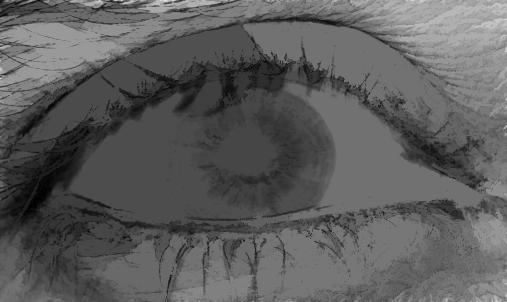
**4.2.21 Results**

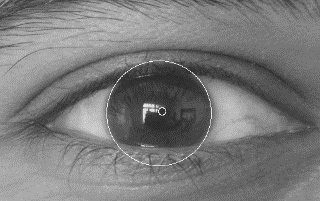
The dataset comprised of 41 images in total obtained by the courtesy of Dr. Kamran of Al Latif Trust. All the images have premature cataract graded by the doctor.

The results obtained by the developed system are approximately 70% accurate. Out of 36 images that were used as testing about 25 of them are correctly classified. Some of the localization results and ROI feature extraction results are shown below in the figure.





­­



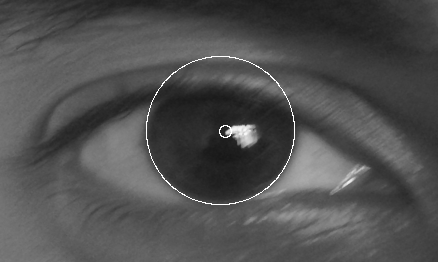


Figure 4.3 Results obtained after application of algorithm on Cataract affected samples.

**Standalone System**

The algorithms for the detection of hemoglobin level of the subject, and the algorithm for the detection of cataract were first simulated in Matlab, software by Mathworks Inc., through research work and literature reviews of the respective diseases. After the desired results were obtained in simulation, we then, as proposed, developed a standalone system for the detection of the two diseases to make it easy to use and provide maximum portability. This standalone system comprised of a smartphone application, developed especially for android based smartphones.

**Mobile Application**

The making of a standalone application comprised of following main steps

* Installation of an Android development IDE
* Configuring openCV library with the IDE
* Porting of code from Matlab to Java

**Android IDE**

Android is a Linux based mobile operating system. Applications for the android mobiles are written using the Android Software Development Kit (Android SDK) along with Java Programming language. An IDE is required to make an application. The IDE must be configured with Java SDK and Android SDK for application development. Android Studio by JetBrain’s IntelliJ IDEA software, released in 2014, (<http://developer.android.com/sdk/index.html> Last Access 29-06-15) is a new IDE for developing android based applications. It has android SDK already configured with it. It provides enhanced features and more functionality in a more user friendly environment. Android Studio was used for our application development.

**OpenCV**

OpenCV is a library developed mainly for image processing in systems that imply real time computer vision. This library comes with a series of functions providing different operations on the images/videos acquired by the real time computer vision systems. These functions help to analyze and extract information from the images/videos that are obtained.

OpenCV library is written in C/C++ programming languages but it can be interfaced with many other languages. OpenCV offers support for Python, Java, Matlab etc. but most of the programs for openCV are usually written in C/C++.

OpenCV also comes in support with android development. It can be interfaced to provide additional functionality in the applications. It needs to be configured first with the Android IDE that is being used for application development. After configuration, the functions provided in the library can be used in the application.

As our proposed application acquires images from the camera and needs advanced image processing for the detection of the subjective diseases, that otherwise cannot be implemented using normal java and android APIs. We configured OpenCV with android studio for image processing purposes.

**Porting**

After configuring openCV with android studio, the Matlab code was converted into the java application.

**EYE XPLORER**

The application developed has two parts. One helps the user to find the value of his/her hemoglobin level in their blood and further informing them of being anemic or not, whilst the other one tells whether the user has a cataract in their eyes. Both these diseases are connected by their relation with the human eye.

* The application has several pages. The start screen prompts the user to choose which disease he/she wants to test.
* After the selection, a questionnaire, separate for both the diseases, appears asking the user simple questions about symptoms that can be observed without using specialized equipment. The user fills the questionnaire and the probability of the questions answered is added to the final result.
* A picture of the required section of eye is taken from the camera
* The picture is then analyzed by the algorithms at the backend of the application
* The end results include a report of the user.
  + In case when user choose anemia, the end report shows the hemoglobin value in the blood. The report also includes information telling the user whether he/she is anemic or not
  + In case when user chose cataract, the report simply tells the user whether he/she has a cataract in their eye.





Figure 4.4: Different tiles of Android Application for Anemia and Cataract respectively

**CHAPTER FIVE**

**Conclusion**

Our proposed system helps the Anemia and Cataract patients to simply detect their risk of being anemic or having cataract by just sitting at their homes, offices or anywhere and using their smartphones. Neither have they needed to visit the hospitals nor the clinical laboratories for observing the conventional invasive method of detecting the hemoglobin values and also the detection of cataract by waiting for time after applying the liquids on the eyes. Eye Xplorer is the android based smartphone application which provides the solution for the detection of anemia and cataract by simply taking a picture of their eye by using algorithms of Machine Learning and Digital Image Processing.

**Contribution**

We collected the dataset for the whole project. The dataset of Anemia was collected via a free blood collection camp in Khanewal, Punjab, Pakistan directed by Dr. Nuzhat Qaiser. The dataset of Cataract was collected by Dr. Kamran from Al-Latif Trust Gujranwala, Punjab, Pakistan. In process of making the application, not only we have did the research work we have also achieved the accuracy of almost 70% for both diseases. We have developed an android based mobile application. Integration of both the codes for Anemia and Cataract was made possible in the application.

**Future Work**

Higher accuracy rates can be achieved by collecting the larger dataset for Anemia and Cataract. After some continued research, other types of Cataract we can also be detected other than premature cortical cataract. Similarly, for Anemia, larger the dataset, higher the precision rate can be achieved.

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[14] ([Anemia Detection Methods in Low-Resource Settings - Path](https://www.google.com.pk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CBsQFjAA&url=http%3A%2F%2Fwww.path.org%2Fpublications%2Ffiles%2FTS_anemia_guide_health_workers.pdf&ei=JcYkVcOQKsLgaLWxgdAE&usg=AFQjCNHqWpnLK94EniBfNLy7zRze1M1x1A&sig2=LydGoVkF3oF5kFgaYXE1cg) [**www.path.org/publications/files/TS\_anemia\_guide\_health\_workers.pdf**](http://www.path.org/publications/files/TS_anemia_guide_health_workers.pdf)Access:9/4/2015)

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