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DETECTION OF DRY EYE USING THERMAL INFRARED IMAGING

INTRODUCTION

Infrared thermography is the method of detecting infrared radiation (electromagnetic radiation) which is emitted from an object and displaying it as a temperature distribution on the image. It is done by without any direct contact with an object. It can be measured in real time over any wide surface area. The thermal sensor array or a thermal camera detects the infrared radiation from the surface of an object and converts it into an electronic signal. It contains information about the temperature. The obtained temperature values are converted into a thermal image with the help of a microcontroller. The thermal images are usually gray scale in nature. Black represents the extreme cold region and white represents the extreme hot region. The shades of gray from black to white represent the change in temperature starting from cold to hot. The color thermal image is obtained by adding pseudo colors to grayscale image for better understanding of temperature difference in each region. The infrared thermal imaging is most widely used for industrial applications and it is highly expensive.

DRY EYE

Dry eye is a condition in which a person doesn't have enough quality tears to lubricate and nourish the eye. Dry eye is a chronic disease which is most often found in older adults. Due to increased cell phone and computer usage, the rates are increasing even in younger population. Tears are necessary for providing clear vision and necessary for maintaining the health of the front surface of the eye. Tears are complete mixture of water, fatty oils and mucus. The mixture helps to protect the eyes from infection and makes the eyes smooth and clear. The loss of this mixture leads to a dry eye condition. The medical term for dry eye condition is known as **keratoconjunctivitis sicca.**

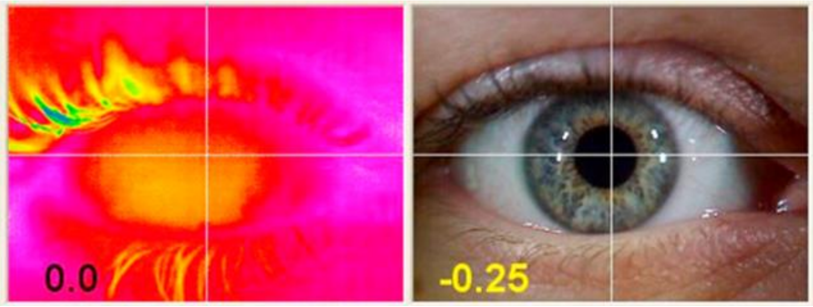


FIG 1: THERMAL AND NORMAL IMAGE OF AN EYE

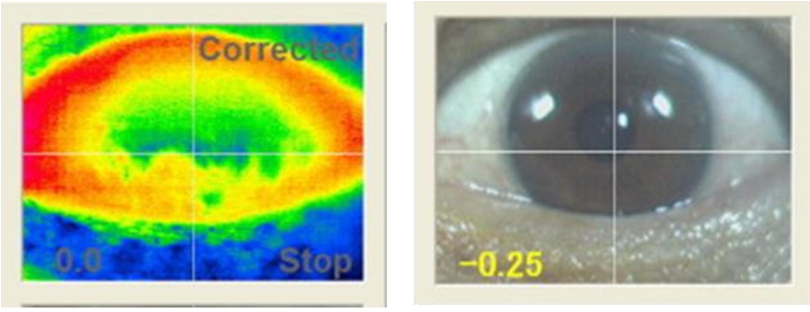


FIG 2: THERMAL AND NORMAL IMAGE OF AN EYE

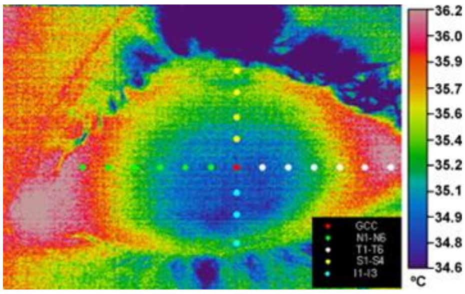


FIG 3: THERMAL IMAGE OF AN EYE

NEED and OBJECTIVE

To diagnose whether a person has dry eye or not from thermal infrared images. Use the already captured images perform image enhancement, segmentation, and extract various features like are Optical Surface temperature of entire eye, Optical Surface Temperature of Cornea and Temperature Deviation along Cornea, and classify them as normal or dry eye images based on threshold found in research papers. The accuracy, sensitivity, specificity calculation of these features are also found as part of our work.

LITERATURE

Rajendra Acharya, Gerk chang Yee et al., (2008) proposed “Analysis of Normal Human Eye with Different Age Groups Using Infrared Imaging.” Cornea masked temperature difference between left and right eyes is more than 0.6°C. Radius of cornea is approximately equal to 1/4th or 25% of entire eye. Temperature deviation along cornea formula is TDC=f(x,y+1)-f(x,y). In this work, 67 IR images of normal subjects of various age groups have been studied. The IR images of the left and right eyes were collected at the biomedical center, Ngee Ann Polytechnic, Singapore.

METHODOLOGY

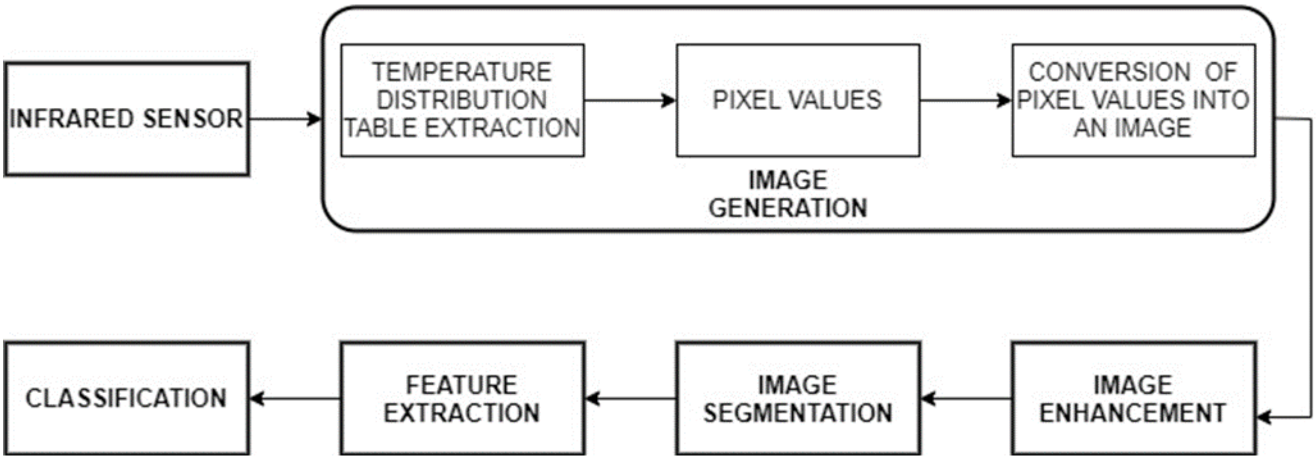


FIG 4: BLOCK DIAGRAM

DATASET

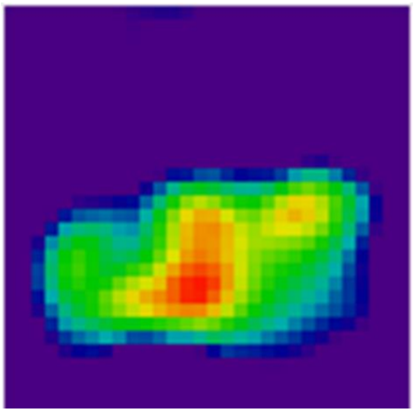
All the images are captured using ADAFRUIT AMGG883 in standard temperature of 25 degree centigrade in a study done by myself at 2020. We had used raspberry pi along with the camera and it is done for a total of 10 subjects. And using distributions of the subjects and features obtained, we created 10 more values to increase the total number of samples which we had.

Following formula was used to increase the number of samples from 10 to 20

Random value =Random value from 0-1 generated

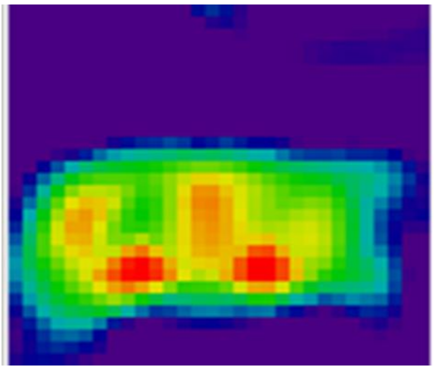
Feature value = (Random value *std dev) + mean

Left Eye Thermal Image

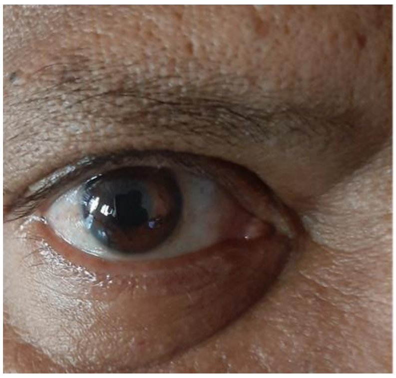


Left Eye Normal Image

Right Eye Thermal Image



Right Eye Normal Image



TEMPERATURE SCALE

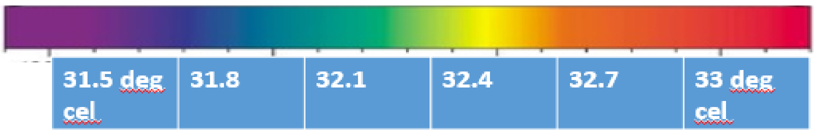
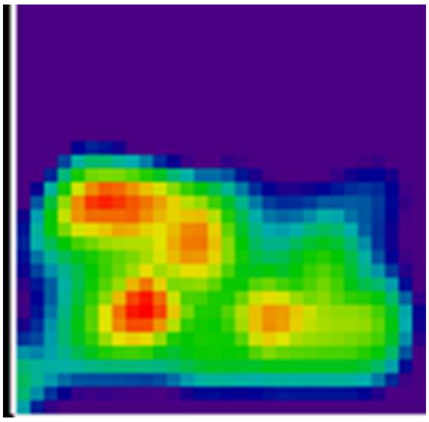


IMAGE ENHANCEMENT

In Image enhancement, input images are sharpened, which provides better enhanced images for further processing.

Original image



Sharpened image

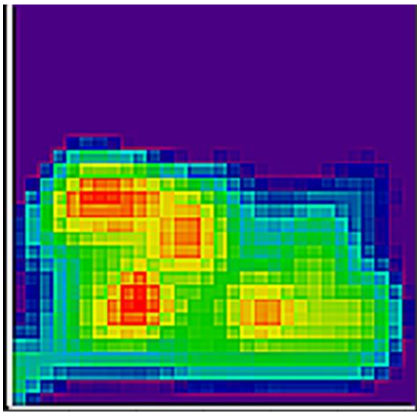
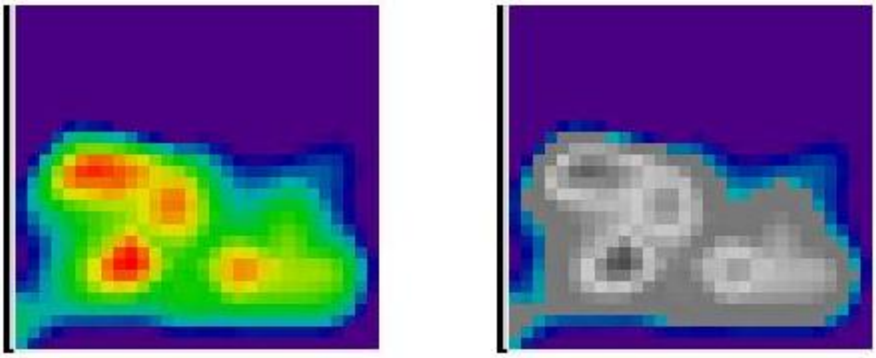


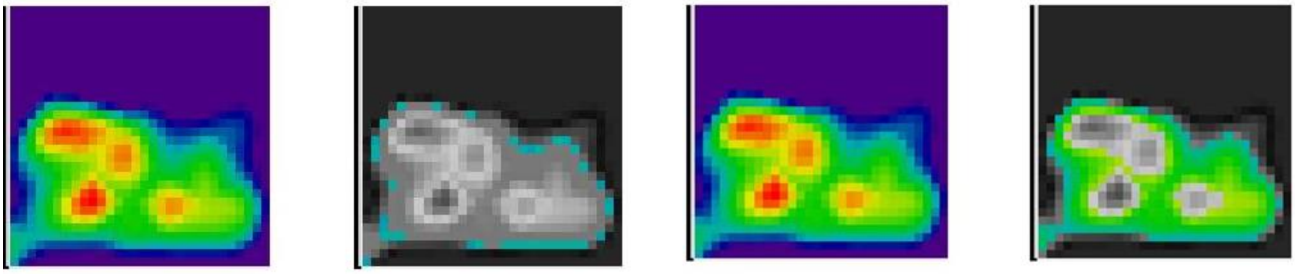
IMAGE SEGMENTATION

VIBGYOR based image segmentation is done to extract different temperature regions according to the feature which are actually required to extract. On applying it different colour regions are separated and it can used to optimize the number of pixels of particular colour which are in turn used to extract features like optical surface temperature, cornea temperature and temperature deviation along cornea.

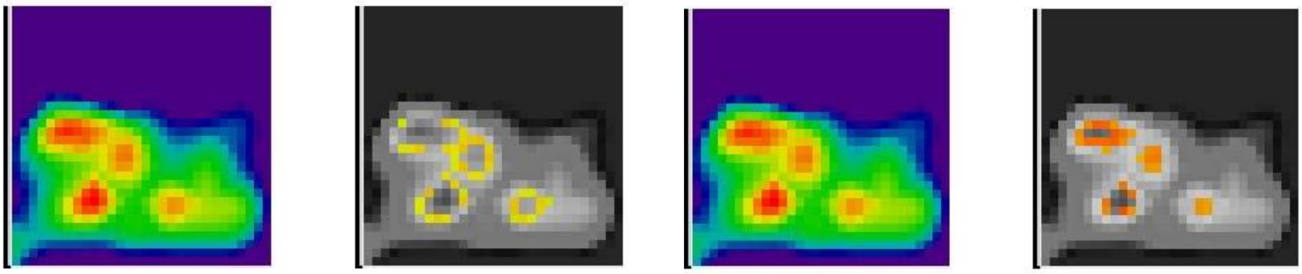
Violet and Indigo segmented Image-Outer eye at 31.5·C



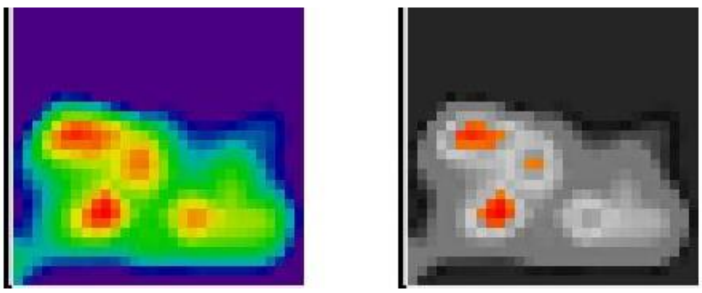
Blue and Green segmented Image at 32.2·C to 32.4·C



Yellow and Orange segmented Image at 32.5·C to 33·C



Red segmented Image at above 33·C



FEATURE EXTRACTION

1. OPTICAL SURFACE TEMPERATURE OF ENTIRE EYE

The entire eye OST is calculated after separation of foreground eye image from background. After segmentation, the number of individual color pixels like blue, green, yellow, orange, red are counted. These colors indicate temperature values in range of 31.8 to 33^0C. The number of color pixels are multiplied with individual temperature values. These values after division by total number of pixels yield average Optical surface temperature of entire eye.

The formula used is:

Sum=((33*R)+(32.7*O)+(32.4*Y)+(32.1*G)+(31.8*B)) ----(3.4)

Divisor=R+O+Y+G+B ----(3.5)

OST=Sum/Divisor ----(3.6)

Where R -number of red color pixels

O -number of orange color pixels

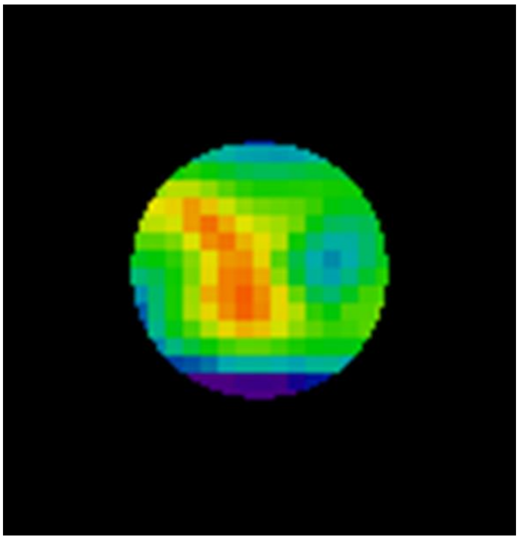
G -number of green color pixels

Y -number of yellow color pixels

B -number of blue color pixels

2. OPTICAL SURFACE TEMPERATURE OF CORNEA

According to a research paper, radius of cornea is approximately equal to 1/4th or 25% of entire eye. A Temperature difference of **0.6ºC** or above between right and left cornea indicates presence of dry eye. This asymmetrical property of cornea is found in patients with dry eye. A mask is created for all images with radius 25% of entire eye, and temperature of cornea part alone is calculated using computer vision library

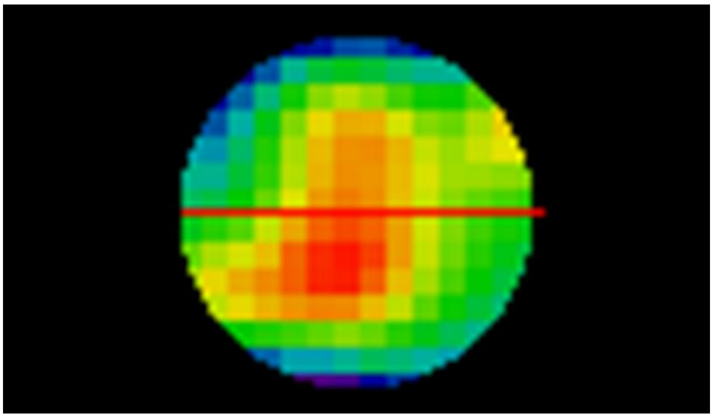


Cornea Masked Image

3. TEMPERATURE DEVIATION ALONG CORNEA

This feature is extracted by creating a line along the diameter of the Cornea, and measuring the temperature change. The research paper shows an accuracy of 0.01^0C, but our camera's accuracy is 0.25^0C. They had stated that 17 temperature variations as normal, which translates to 5.1^0C. Information about each pixel along line is obtained and feature value is calculated using the formula below. The feature is calculated along the red line indicated

$$\mathbf{TDC=f(x,y+1)-f(x,y)}$$



Temperature deviation along Cornea image

CLASSIFICATION AND METRICS

Various Machine learning algorithms are tried and various metrics obtained for test sets are listed below

S.No	Model	Accuracy %	Recall% for diseased class	F1 Score %
1	Logistic Regression	100	100	100
2	Gaussian Naïve Bayes	100	100	100
3	Support Vector Machines	100	100	100
4	Decision Tree	100	100	100
5	Random Forest	100	100	100
6	Extra Trees	100	100	100
7	XG Boost	100	100	100
8	**Light GBM**	**75**	**0**	**43**

The metrics tells us that all models perform well even without hyperparameter tuning indicates the **models are overfit** and thus it would be better if we can repeat the same experiment for more samples for generalize it. But **LightGBM** gives poor metrics among all models with **F1 score** of **43%**

FUTURE WORKS

In future, we would like to do similar study on a large number of subjects and this in turn causes our models to be correct fit generalizing to the general population.

SUMMARY and CONCLUSION

Thus, we processed our infrared imaging and extracted three features and used different types of Machine learning models to classify it. And we found that there are smaller number of samples and therefore all the models built are over fit. But **LightGBM** gives poor metrics among all models with **F1 score** of **43%.**