# EYE TUMOUR DETECTION USING DEEP LEARNING

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***Abstract*** **-Iris melanocytic tumours, are the most dangerous tumours in the eye , commonly known as eye tumours. This includes freckle, nevus, melanocytoma, Lisch nodule, and melanoma. The detection of eye tumour is very difficult in early stages. Many research works are being carried out to detect eye diseases. But few research works in the eye tumour were published. Most of the system needs specific data acquisition devices to capture the region. This is very expensive. To diagnose eye melanoma, doctors recommend PET - CT, eye ultrasound, angiogram, optical coherence tomography, etc. Here, a new approach is presented to detect the eye tumour from eye images using deep learning technique. The deep network model created with modified LeNet architecture. The model created with the segmented eyeball images. Hough circle transformation could predict the eyeball and iris regions. As the deep learning technique needs more data for training, the number of image data has been increased with image augmentation method. Successful testing of this method with an accuracy of 95% shows that this method can be implemented in real time applications.**

***Keywords- Ocular Melanoma, eye tumour, Cancer, Deep learning algorithm, CNN, LeNet, hough circle, grayscale conversion.***

## I. INTRODUCTION

Iris melanocytic tumours are the most dangerous tumours in the eye, commonly known as 'eye tumours'. This includes freckle, nevus, melanocytoma, Lisch nodule, and melanoma [1]. The term ocular is used with tumour to represent that it is accompanied with eye. It can be intraocular, which means inside the eye or extra-ocular which means that it affects the outside part of the eye. The most common types of the intraocular iris tumours are the Cyst, Nevus, and Melanoma [2]. Some other tumours related to the eye are Lacrimal Gland Tumour, lid tumour, etc. The exact cause of this disorder is not known, but certain risk factors have been noticed. The disorder is seen more often in people who have light eye colour [3]. Age, certain inherited skin disorders, exposure to ultraviolet (UV) light, certain genetic mutations etc are also considered as the reasons for eye tumours. The eye tumour can be spread and shall affect the vision.

Routine checkups are the best methods for diagnosing the tumour. Retinoblastoma, the eye tumour, can be identified with naked eye [4]. Ophthalmoscope is commonly used to diagnose. Ultrasound, Fluorescein angiography test OCT, Semiconductor Detectors are the other common methods to diagnose. Needle biopsy is rarely used for diagnosis. CT and MRI are best in diagnosing extraoccular and intracranial extension. Diagnosis of eye tumours is considered according to age, health state, suspected disease, symptoms and past examination records. Cytogenetics and gene expression profiling are used to collect more information about prognosis. Iris tumours are most common eye tumours and it is classified into different types. For earlier detection of these tumours, generalised procedure is needed to diagnose the abnormality.

The two most commonly used therapeutic procedures are surgery or radiation therapy. In Radiation therapy damage produced in the tumour cells causes them to die and slowly shrink. The most common radiation therapies are endocrine therapy, brachytherapy, or sealed source radiotherapy [5]. Shrinking of the tumour region can be completely cured with local therapy. The local therapy consists of laser photocoagulation, cryotherapy, thermotherapy, Plaque radiotherapy etc. Laser photocoagulation is the primary therapy with xenon or argon arc. This coagulates all blood supply to the tumour and it can control 70% of the abnormality. Cryotherapy commonly treated for small tumours. The procedures for chemotherapy start with cryotherapy as a preparation step. Thermotherapy is the method of applying heat to the affected area using ultrasound, microwaves, or infrared radiation.

(a)

(b)

Figure 1: Iris camera and setup (a) Miles Eye Camera MEC-5 (24 megapixel) (b) CRCS-FH4 model Premium Professional Chinrest/Camera [Courtesy: MilesResearch Products]

Ophthalmology is a branch of medical science that investigates the disorders of the eye. Bio medical imaging software is the efficient tool for ophthalmologists in diagnosing eye diseases. These imaging techniques also help them in surgical treatment. Most of the image diagnosing machines are working with the principle of machine learning. Fundus and OCT image records can reveal the symptoms of diabetes. Many cameras are available now for capturing iris regions of the eye. These images are used both for biomedical and biometric applications. Figure 1 shows the images of one iris camera and its setup for capturing the images. The demonstration of this camera setup is illustrated here to only get an idea for capturing such images. The eye

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tumour examinations can be undertaken with these cameras. More research works should come across in the field of iris tumour detection

## II. EXPERIMENTAL METHODS

In this paper [6], the author proposes an image processing technique to identify the eye tumour. This experiment was conducted with 30 normal and 70 tumour images. The median filtered image segmented into two parts. Canny edge detection and image fusion methods are implemented in locating the affected area.

In this paper [7], the author investigates the symptoms of eye tumour similar to glaucoma with biomedical imaging. The author analysed this case with 9 patients and identified that eye tumours are misdiagnosed as glaucoma. They might be mistaken for glaucoma because of similar symptoms such as pain, severe headache, red eye, etc. In this study, they insisted on the importance of diagnosing tumours correctly by comparing nine cases misdiagnosed as glaucoma initially.

Here [8] the author presented automated methods to segment iris images for early detection of eye tumour. Vander Lugt corelator based active contour method is used to segment the iris portion. K-means clustering model is used to label the tumorous tissue.

(a) (b)

Figure 2: Eye Images (a) Normal (b) tumour

## III. PROPOSED METHOD

Deep learning techniques are mainly employed in the detection of eye tumour. Figure 3 shows the pipeline of the proposed method.

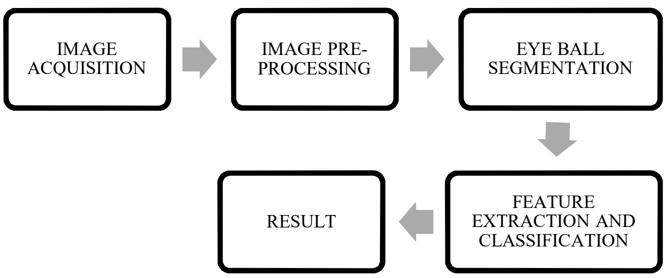



Figure 3 : Pipeline of the system

### A. Image acquisition

Image acquisition is the advent of a digitally encoded illustration of the visible traits of an object, consisting of a bodily scene or the interior shape of an object. The term is frequently assumed to mean or encompass the processing, compression, storage, printing, and display of such images. As eye tumours have different types, many open dataset are available for research purposes. Only a limited number of image data are available for study. The images were collected from Miles Research, Eye cancer and uveal melanoma image databases. We have prepared 100 abnormal and 100 normal images after analysing the disease conditions. More data is needed for deep learning techniques. So image augmentation technique is applied to increase the number. Augmentation step contains a rotation of each image, width shift range of 0.1, height shift range of 0.1, brightness range of (0.3,1.0), horizontal and vertical flip. A new dataset has been created with 2000 images.

### B. Image pre-processing

Image pre-processing step aims to prepare the input data for further analysis. It may use automated algorithms. Filtering is a vital procedure in signal processing, for outlining the capabilities of image, filtering suppresses completely or partially some elements of image. Image pre-processing mainly depends with the source. Two parameters influence the picture quality. Intrinsic parameters are related with materials made and extrinsic parameters are related with the environment where the image captured [9]. Most of the images are in RGB format. Gray scale conversion is needed for converting the image into two dimensional arrays. Gray scale conversion methods are based on average, lightness and luminosity [10]

Let R, G, B are the colour planes of an image.

$$\text{Average} = \frac{(R+G+B)}{3} \tag{1}$$

$$Lightness = \frac{(\max(R,G,B) + \min(R,G,B))}{2} \tag{2}$$

$$luminosity = 0.21\,R + 0.72\,G + 0.07\,B \tag{3}$$

### C. Eyeball segmentation

Segmentation is the process of splitting the entire image into different parts. Here eyeball is the region of interest (ROI) where the features of tumours exist. As the iris region is in circle shape, Hough circle detection is employed to separate the ROI [11]. The Hough transform is a technique of feature extraction which is used in many processes like digital image processing, image analysis, and computer vision. Two circle regions are inside the eyeball. The outer region can be easily separated and the inner region may not clear in diseased image. So outer circle detection is prioritised. Canny based edge detection algorithm prepares the boundary of these regions. Gradient of the images extracted by applying different threshold values [12].

A Hough circle is the transformation of all circular shapes to lines. This helps to identify the number of circles in an image. Circle is commonly represented as

$$(x-a)^2 + (y-b)^2 = R^2 \tag{4}$$

$$x = a + R\cos(\theta) \tag{5}$$

$$y = b + R\sin(\theta) \tag{6}$$

a and b are the centre points of the circle, R is the radius, θ is the angle.

The hough transformation finds the probability of a circle within the radius. A search program is associated to find the intensity points within a circular shape and collects probable circle points. The maximum and minimum radii can also be selected. Radius of the eye related to the eye structure of humans, distance between camera and eye and camera parameters. For a particular dataset, it should be in a particular range. Figure 4 shows the circle segmentation in iris images.

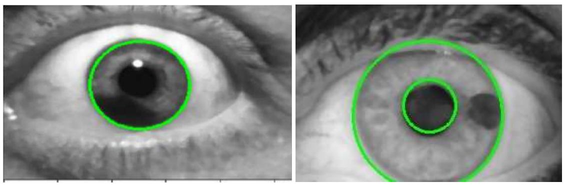


Figure 4: Circle detection using Hough transform

D. Feature Extraction and Classification

In machine learning, feature extraction and classification are two separate processes. The common features of melanoma are Asymmetry, Border irregularity , color, texture, etc [13]. In the conventional ML approach, different features like mean, variance, standard deviation, texture pattern, etc can be selected from the ROI and then proceed with a classifier like SVM, Naïve Bayes, ANN etc[14]. In deep learning the entire ROI is put in a deep neural network model where the feature extraction and classification are simultaneously processed [15].

Convolutional Neural Networks (CNN) are the efficient deep learning networks for computer vision based classifications. It can be easily implemented with highest accuracy. LeNet is a gradient based learning network with multiple layers that is derived from CNN. CNN integrated three architectural designs to establish shift, scale and distortion invariance [16]. These algorithms can classify eye tumour patterns with certain modifications. Figure 5 shows the general architecture of CNN. The following four layers do the function of feature extraction and classification [17].

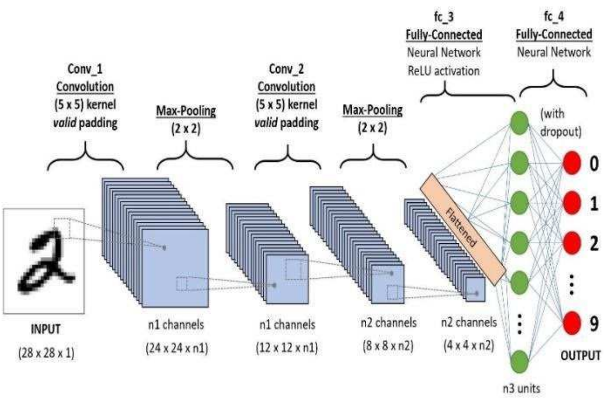
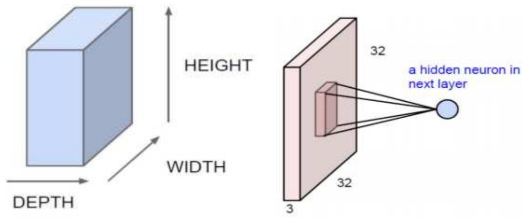



Figure 5: CNN general architecture

*i) Convolutional Layer*

The Convolutional layer is the basic building block of a Convolutional Network. It involves different functions like Local Connectivity, Spatial arrangement and Parameter Sharing.

Local Connectivity – Connecting neurons from one layer to others is seen as unrealistic, as it increases the parameter size and computational cost. In the CNN approach, every neuron creates a local connection to other neurons. Filter size is a hyper parameter which establishes the connectivity range. This parameter is similar to the depth of the input.




(a) (b)

Figure 6: (a) 3D Input representation of CNN (b) Convolution as alternative for fully connected network

Spatial arrangement - The parameters controlling the size of output are depth, stride and zero-padding. The number of filters to be used is the depth. The amount by which the filter is slided is known as stride. For stride of 1, filters are moved one pixel at a time. For stride of 2, filters move 2 pixels at a time. Thus the output volumes we get are smaller spatially. The amount of zeros with which we pad the input around its border is known as zero padding. This also gives us control over the size of the output spatially. The size of the output is given by $(2P+W-F)/S+1$, where $P$ = zero padding amount, $W$ = input size, $F$ = receptive field size of neurons, $S$ = stride.

Parameter Sharing - Each neuron computes the gradient corresponding to its weights, but these gradients get added along each depth slice and only a single set of weights are updated per slice, during back propagation.

2. Pooling Layer

This layer gradually diminishes the spatial size of representation along with the number of parameters and computational cost in the network. It controls over fitting. The layer operates individually on each depth slice of input and resizes it by MAX operation. Most commonly it has filters of size 2x2, stride of 2 and down samples each depth slice by 2 along the width and height. It adds no parameters since it calculates a permanent function of the input. Besides max pooling, this unit can also compute average pooling or L2-norm pooling.

3. Non-Linearity Layer

A non-linear activation function which maps the feature map created by the previous Convolutional layer to an activation map is composed of this layer. It is an element-wise operation on the input such that dimensions of input and output are matching. Examples of such functions are sigmoid (logistic), hyperbolic tangent, rectified linear units (ReLUs) etc.

4. Fully-connected layer

Complete connections to all activations in the previous layer are present in this layer, as in usual Neural Networks like Multi-Layer Perceptron. Their activations can be computed with a matrix multiplication followed by applying a bias offset.

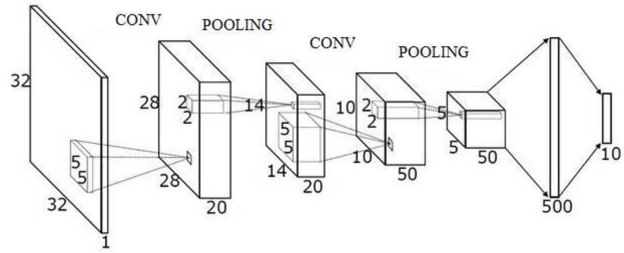



Figure 7: Modified LeNet architecture

## IV. RESULTS AND DISCUSSIONS

The aim of this method is to classify the healthy and eye tumour images. Uveal melanoma is a type of eye tumour which is mainly seen in the iris, ciliary body, or choroid. Tumours arise from the pigment cells that are melanocytes which exist within the uvea giving color to the eye. These melanocytes are different from the other retinal epithelial cells originating in the retina that do not form melanomas. With augmentation technique, 2000 images were generated . We used Keras and Tensorflow in Python . Google Collab was our workstation.

For training, 80% of data (1600) was used and for validation and testing, 10 % of data (200) for each was used. Number of epochs = 50, learning rate = 0.001, Batch size = 32, optimizer = "Adam", loss = "binary cross entropy". Hyper parameters were tuned by GridSearchCV method of sklearn library. As the amount of data was adequate, we did not need further data augmentation.

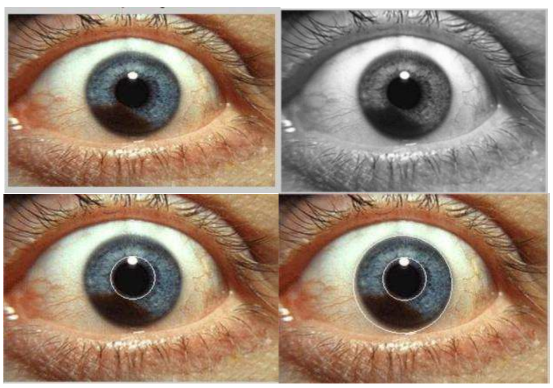


Figure 8: (a) original image (b) Gray scale image (c) pupil detection (d) iris detection

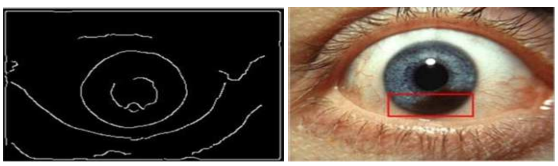


Figure 9: Edge detection and tumour region

Receiver operating characteristic curve is a measure of performance of the system. It plots the true positive rate over false positive rate. The ROC curve in Figure 11, the performance of the model taking Normal condition as class one. Area under the curve is 0.98. Similarly ROC curve shown in Figure 12, treats Tumour condition as class one, Area under the curve is 0.95.

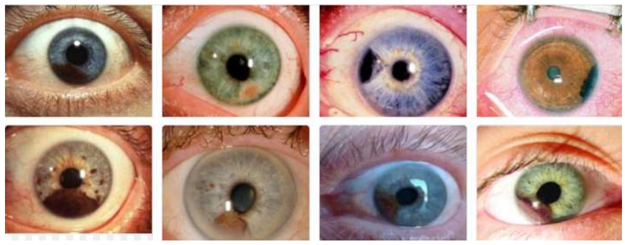


Figure 10: Tumour images in the dataset

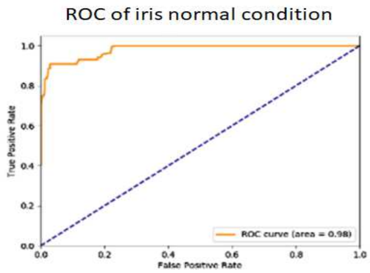



Figure 11: ROC plot of Normal Condition

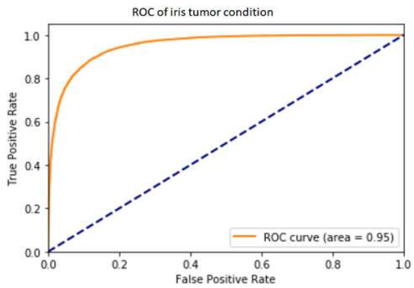



Figure 12: ROC plot of Tumour Condition

$$Accuracy = \frac{(TP+TN)}{(TP+TN+FP+FN)} = 95\ \%$$

$$Sensitvity = \frac{TP}{TP+FN} = 97.87\ \%$$

$$Specificity = \frac{TN}{TN+FP} = 92.45\ \%$$

## V. CONCLUSION

Research work in ocular tumour or tumour needs more attention in the present world. Many open sources are available for this research work. We selected eye tumour images from different databases for study purposes. We have developed deep learning algorithm with modified LeNet architecture which is a novel work in the field of eye tumour detection. Our method classifies the normal images with 98% accuracy and abnormal images with an accuracy of 95%. Both of these results show that our model is able to distinguish well between

Tumour and Normal condition. Our system can be effectively implemented into real life applications.

More research works are expected to come across in the identification eye tumour. As the iris cameras are used for different purposes, more dataset shall be taken and shared for research purposes. Hospitals can implement eye tumour detection systems using iris cameras. It can be also implemented in real time mobile applications. More features can be analysed through machine learning algorithms.

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