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Automated Heart Dysfunctionality Identification Based on Iris using Deep Learning

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Abstract: One of the most deadly diseases in the world is Heart Disease. The dysfunctionality of the heart at the early stage can be detected using iridology. The study of iridology describes the structure of the human iris as an observation of the condition of organs in the body. In this article, we explore the heart condition through a series of stages such as iris localization, segmentation, extraction of region of interest, histogram equalization and classification using convolutional neural network. The results are evaluated using various quality metrics such as precision, recall, f-score & accuracy.

Index terms: Iridology, convolutional neural network, segmentation, ROI (Region of Interest), histogram equalization, down-sampling, classification.

I. INTRODUCTION

According to WHO [7], heart disease has remained the leading cause of death and about 66% of deaths occur due to Cardiovascular disease in people aged above 70. Usually, the heart disease is recognized when the person's condition is severe and the healing process is delayed. The methods such as blood tests, ultrasonography, and CT scan, etc., are costlier and intrusive. At this stage, there are chances of losing the patient. In this scenario, if the person's heart condition is known at the earlier stage then there are chances for preventing the person's health condition becoming severe. Iridology is a system of diagnosis, which was invented by Ignatz Peczely in 1893. Iridology science states that the iris of human eye maps to various organs in the body in some way to detect the health status of organs in the body. Through iridology only the abnormality of the organ can be detected but the severity or the depth of dysfunctionality of the organ cannot be detected. The condition of an organ can be found by comparing the iris of human with the iris chart which shows location of organ as shown in Fig.1. The heart is positioned at clockwise direction between 2:00 to 3:00 in left iris.

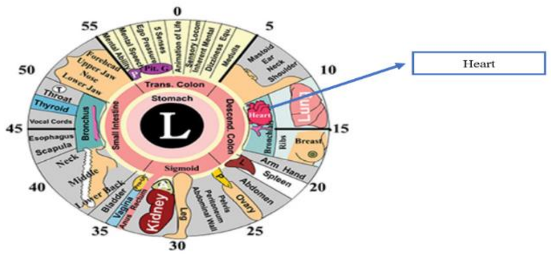

Fig-1. Iridology chart showing heart region in left eye

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Lintang Indah Permatasari et al., [1] experimented with a classification method for detecting heart disorder through iris using SVM and achieved an accuracy of 80%. R.G.Alam Nusanatara Putra Herlambang et al., [2] conferred a method for feature extraction using back-propagation neural network with Grey Level Co-Occurrence Matrix achieved an accuracy of 91.42%. Nor'aini A.J.i et al., [3] illustrated a method for classifying vegina & pelvis from iris using Principal Component Analysis and SVM. Borders of the inner-pupil and outer-iris were localized and segmented with a new circular Boundary Detector method with an accuracy of 75% for classification of both vegina and pelvis.

Tassadaq Hussain et al., [4] suggested an SVM method that can identify dysfunctional in lungs. Employed a Gabor feature-based blob for feature extraction based on different colour contrast pattern which obtained an accuracy of 88%. David Habsara Hareva et al., [5] experimented with Artificial Neural Networks (ANN) architecture for predicting abnormalities of organs and yielded good results than state-of-art works. Entin Martiana k. et al., [6] suggested a new approach for histogram equalization to detect the iris region in order to auto-crop the iris of eye which achieved 40% accuracy in cropping iris of eye.

As per the literature, many traditional and neural network-based methods were used to address the problem of finding abnormalities in human body through iris. In this article, we suggested a model based on iridology science for heart abnormality using deep convolutional neural network methodology through a series of pre-processing steps such as iris localization, segmentation, extraction of region of interest, histogram equalization and classification using convolutional neural network to improve the accuracy of the model.

This article is ordered as follows: Section II, introduces about convolutional neural network. Section III, explains methodology. Section IV, introduces about dataset. Section V, elucidates about experimentation. Section VI, discusses about experimentation results and the conclusion & future work are highlighted in Section VII.

II. DEEP CONVOLUTIONAL NEURAL NETWORKS

In deep learning, a convolutional neural network is a class of deep neural networks that are most customarily used to analyze visual images. CNN makes use of little pre-processing as compared to other image processing algorithms. This means that the neural network learns filters on its own that are hand-engineered filters in traditional algorithms. This independence is a major advantage of advance knowledge and human effort in feature design.

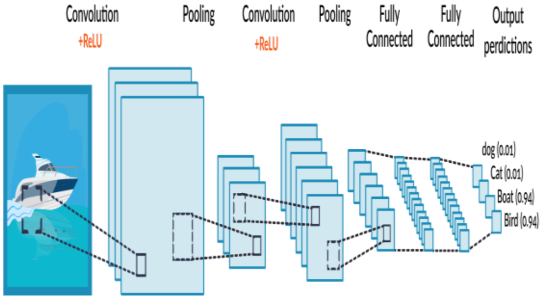

Fig-2. A sample CNN architecture

CNNs are similar to a regular neural networks which are made up of neurons with learnable weights and biases. The difference between CNN from a regular multilayer perception is its use of convolution layer, pooling operation and optimization methods. CNNs have achieved skilful performance in medical image analysis.

III. METHODOLOGY

The following steps are to be considered for effective identification of disorder in heart through iris as shown in Fig.3.

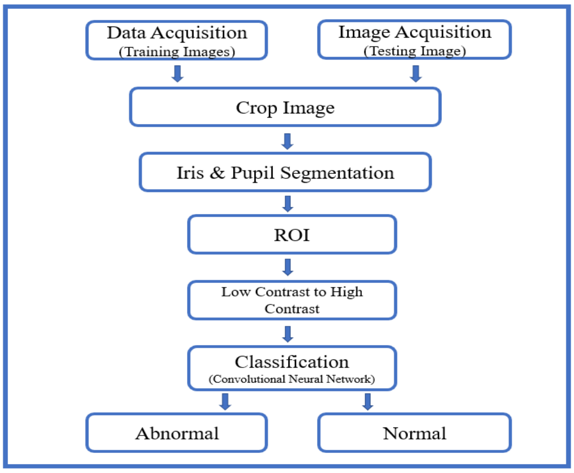

Fig-3. Flow chart of the system

A. IMAGE ACQUISITION

The image is collected using slitlamp device where the image will look as shown in Fig.4.

Fig-4. Image taken from slit lamp device

B. IRIS LOCALIZATION

The area between sclera and pupil is called the iris, where the outer border of pupil and inner border of sclera are non-concentric circles. Daugman (1993) proposed a circular edge detection operator for localization of iris which is given as,

$$\max_{(r,x_0,y_0)} \left| G_\sigma(r) * \frac{\partial}{\partial r} \oint_{r,x_0,y_0} \frac{I(x,y)}{2\pi r} ds \right| \quad (1)$$

The localized image by using above method is shown in Fig.5.

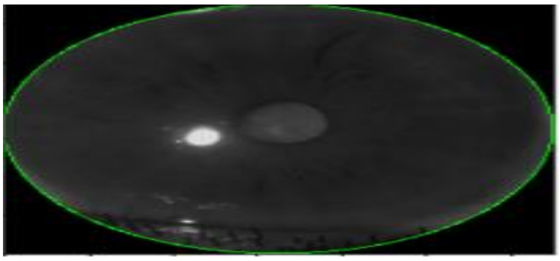

Fig-5. Localized image

C. SEGMENTATION

Segmentation is the process of pixel by pixel classification for seperating iris and pupil regions. The circular Hough Transform is applied to find the pupil and sclera boundaries in the form of centre and radius of the circles which is given as,

$$x^2_c + y^2_c - r^2 = 0 \quad (2)$$

Where x_c and y_c are center coordinates and r is the radius which are able to define any circle according to the equation. with these centre and radius values the iris region is segmented which is shown in Fig.6.

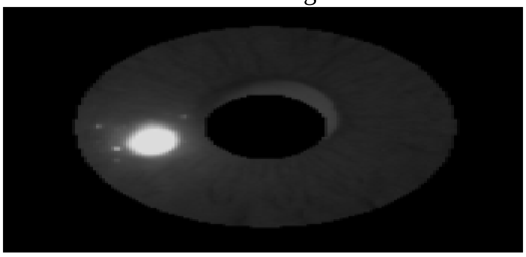

Fig-6. Segmented iris

D. REGION OF INTEREST

Extracted region of interest i.e., heart region from the segmented iris image which is located at clockwise direction between 2:00 to 3:00 is as shown in Fig.7.

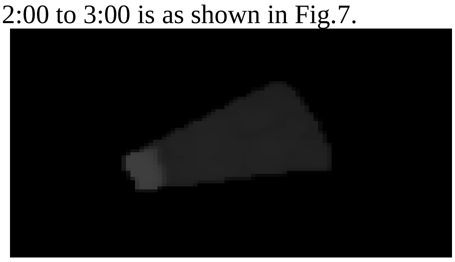

Fig-7. Extracted heart region

E. HISTOGRAM EQUALIZATION

Histogram equalization is a process of tuning image intensities to intensify the contrast of the image. The extracted ROI is intensified using histogram equalization technique to identify the features accurately which are given as,

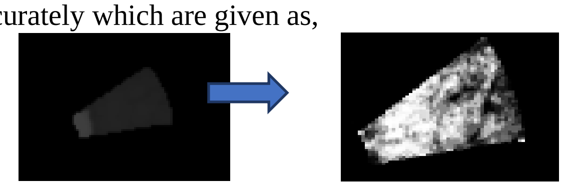

Fig-8. Transformation from low contrast to high contrast image

$p(\gamma_j) = \frac{n_j}{n}$, j=0, 1, 2, 3, ……, L-1 (n = total no. of pixels in image) (3)

$S_k = T(\gamma_k) = \sum_{j=0}^{k} P(\gamma_j)$, k = 0, 1, 2, ……, L-1 (Cumulative probability Distribution) (4)

$S_k \Leftarrow (L-1) * S_l$

F. CONVOLUTIONAL NEURAL NETWORK

In this article, we implement a CNN model whose architecture is shown below:

(1) Input: 64 x 64 x 3
(2) Conv2D: size 3 x 3, filters 32, stride 1
(3) ReLU: max (0, hθ (x))
(4) Pool: size 2 x 2, stride 1
(5) Conv2D: size 5 x 5, filters 64, stride 1
(6) ReLU: max (0, hθ (x))
(7) Pool: size 2 x 2, stride 1
(8) FC: 256 hidden neurons
(9) Dropout: p = 0.5
(10) FC: 10 Output Classes

The convolutional layers consist of 3x3x3 and 5x5x3 filters which slides over the image w.r.t image width and height and performs dot product operation on input's image while learning the model parameters. The pooling layer decreases the input images size w.r.t to convolutional filter which inturn reduces the model parameters – called as *down-sampling*. ReLU is the most commonly used activation function implemented using thresholding matrix values at zero which is given as,

$$f(h_\theta(x)) = h_\theta(x)^+ = Max(0, h_\theta(x)) \quad (5)$$

IV.DATASET

We have experimented the proposed methodology with 40 patients data in which 25 patients are having heart abnormality and 15 patients are not having heart abnormality.

V.EXPERIMENTATION

For the experimentation with the proposed model based on Convolutional Neural Network presented in section II of the article, the image scanned from slitlamp device is taken as input and preprocessed for extracting ROI and the extracted ROI is passed on to the CNN model which is presented in section III of the article, to classify whether the image belongs to the category of having heart disease or not.

The overall experimentation is carried out in Anaconda tensorflow environment and the obtained results are evaluated using various evaluation metircs presented in section VI of the article. The obtained results are compared with the state-of-art models such as XGBoost and Random Forest.

VI.EVALUATION METRICS & EXPERIMENTATION RESULTS

For performance evaluation of the proposed model, different evaluation metrics are considered such as Accuracy, Precision, Recall, F-Score.

Accuracy = (TP+TN)/(TP+TN+FP+FN) (6)
Precision = TP/(TP+FP) (7)
Recall = TP/(TP+FN) (8)
F-score = (2*Precision*Recall)/(Precison+Recall) (9)
TP: No. of images correctly classified as abnormality.
FP: No. of images incorrectly classified as abnormality
TN: No. of images correctly classified as no-abnormality.
FN: No. of images incorrectly classified as no-abnormality.

Table-1. Results showing the comparison of performance of models

Metrics/ Methods	XGBoost	Random Forest	CNN
Precision	**90**	**95**	**99**
Recall	**60**	**72**	**75**
F-Score	**75**	**82**	**86**
Accuracy	**60**	**78**	**81**

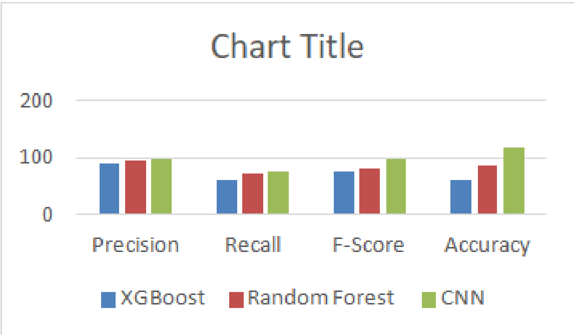

Fig-9. Chart showing the performance of experimented algorithms

VII.CONCLUSION & FUTURE WORK

In this article, we have compared the experimented results for heart abnormality detection through iris using a deep learning model with Random forest & XGBoost algorithms. The obtained results stated that the CNN has performed better in comparison with other state-of-art algorithms and achieved an accuracy of 81%. In future work, the proposed model can be extended for different organs abnormality identification.

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