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An Effective Model for Detection of Dysfunctionality in Heart Based on Iridology using Deep Neural Networks

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Abstract: In today's world heart disease is the primary reason for deaths. WHO has anticipated that 12 million people die every year because of heart diseases. Every organ of the body is represented in the iris in a well-defined manner. The Iris is a micro-structure of the entire body. The abnormality of the heart can be detected using Iridology science. In this article, we examine the heart dysfunctionality through a chain of steps which are localization of iris, segmentation of iris, ROI extraction, histogram equalization of ROI and classification using deep convolutional neural network. The results are assessed based on various standards such as precision, recall, f-score & accuracy.

Index Terms: Cardiovascular disease (CVD), Iridology, CNN (Convolutional Neural Network), VGG16 (Visual Geometry Group), Down Sampling, Localization, Segmentation, ROI (Region of Interest), histogram equalization, Classification.

I. INTRODUCTION

Cardiovascular diseases (CVD) generally refers to a disease of blood vessels or heart. Cardiovascular diseases are primary cause of deaths in the world. It is approximated that 90% of cardiovascular diseases may be avoidable by avoidance of tobacco, exercise, healthy eating etc., but for early detection of cardiovascular diseases there are no measures.

Iridology is another medicine technique whose patrons claim that the examining of iris can figure out patient's health condition. The iridologists correlate their observations to iris chart, which is divided into zones that corresponds to each part of the human body as shown in Fig-1. Iridological "readings" are done by iridologists to evaluate a person's health condition and as a way to improve their health. Iris reveals the changing state of each organ of the body. Iridologists use slit-lamp microscope device for examining patient's iris for tissue changes. 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.

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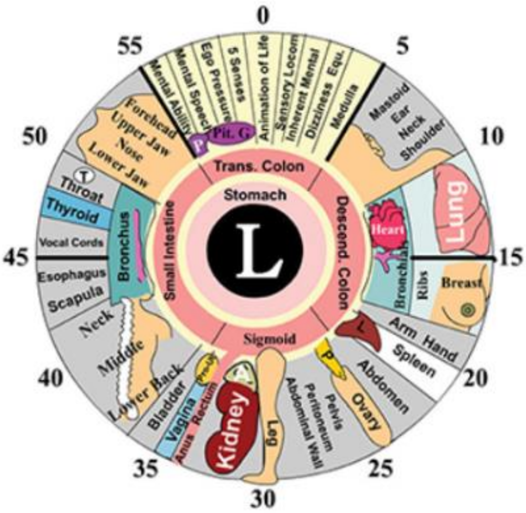

Fig-1. Iridology Chart

Entin Martiana k. et al., [1] suggested a new approach for histogram equalization to detect iris region for auto-cropping the iris of eye which achieved 40% accuracy in cropping iris of eye. Nor'aini A.J.i et al., [2] illustrated a method for classifying vegina & pelvis from iris using Principal Component Analysis and SVM. Borders of the pupil's inner region and iris outer region are localized and segmented with a new circular Boundary Detector method with an accuracy of 75% for classification of both vegina and pelvis. Lintang Indah Permatasari et al., [3] experimented with a classification method for detecting heart disorder through iris using SVM and achieved an accuracy of 80%. 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%. Dyah Ceni Adelina et al., [5] suggested a methodology using image processing techniques like adaptive median filter & gray level co-occurrence matrix along with backpropagation neural networks for detection of diabetes and achieved an accuracy of 82.3%. R.G.Alam Nusanatara Putra Herlambang et al., [6] conferred a feature extraction method with backpropagation neural networks using Grey Level Co-Occurrence Matrix which achieved an accuracy of 91.42%. David Habsara Hareva et al., [7] developed a smart device for detecting heart, lung, spleen & liver conditions using Artificial Neural Networks and achieved better performance than conventional methodologies.

Mahmud Dwi Sulistiyo et al., [8] proposed a methodology using cascade neural network to determine symptoms of Dyspepsia and obtained an accuracy of 95%. I Putu Dody Lesmana et al., [9] experimented with image processing techniques for feature extraction and used backpropagation based on adaptive learning parameters for pancreas disorder detection which obtained an accuracy of 83.3%. Aisyah Kumala Dewi et al., [10] experimented with principal component analysis for feature extraction and classified the obtained features using Backpropagation Neural Network for detecting the presence or absence of disturbances in stomach and yielded good results than the state-of-art works.

According to literature**,** many conventional and deep neural network-based methods were used to address the issue of detecting dysfunctionalities in human body through iris. In this article, we suggested a model based on the study of iridology science for heart dysfunctionality detection through deep neural network methodology through a chain of steps as localization of iris, segmentation of iris, ROI extraction, histogram equalization of ROI and classification using deep neural network to improve the performance of the model.

This article is ordered as follows: Section II of the article elucidates the introduction to deep convolutional neural networks. Section III of the article describes about dataset. Section IV of the article illustrates the proposed methodology. Section V of the article explains about the experimentation. Section VI of the article describes the experimental results and Section VII concludes the article.

II. DEEP CONVOLUTION 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. The artificial neural network attaches importance in the form of learnable weights and biases to objects in the image and can distinguish them from others. Convolutional Neural Networks uses small pre-processing techniques compared to conventional image processing algorithms. The filters that are hand-engineered in conventional methods for feature extraction are learnt by the neural networks on their own which is a major advantage of deep learning over conventional methods. This feature engineering is done with convolution layer, pooling layer, dropout, activation function and fully connection layer.

Convolution is an application of filter to an input which leads to an activation. Applying the same filter continuously to input leads to a map of activations called feature map, which indicates the strength and position of features detected in the input, which is an image as shown in Fig-2.

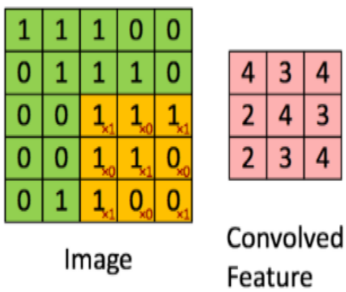

Fig-2. Convolution Operation

The pooling layer is designed to “stack” features obtained from maps created by convolution filter over the image. Formally, its function is to gradually reduce the spatial size of the representation in order to reduce the parameters and computational operations in network. There are three categories of pooling namely max pooling, mean pooling ang sum pooling. For max pooling with filter size 2x2, we place a 2x2 box in upper left corner and move in a row. For every 4 cells in which your table is located, you will find the maximum numerical value and insert it into the map of grouped entities as shown in Fig-3.

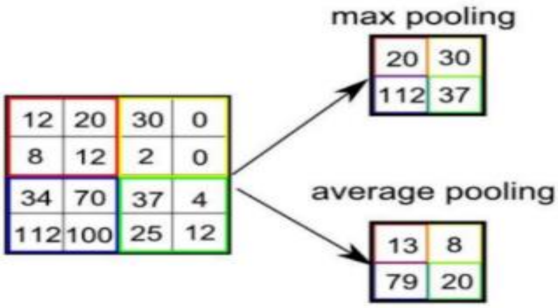

Fig-3. Pooling Operation

ReLU (Rectified Linear Unit) is an activation function which is linear for positive values, and zero for negative values. The ReLU activation is to increase the linearity in images as the images are basically non-linear. The rectifier breaks up the non-linearity in images to build the linearity that is imposed on images when they are put into a convolution operation as shown in Fig-4.

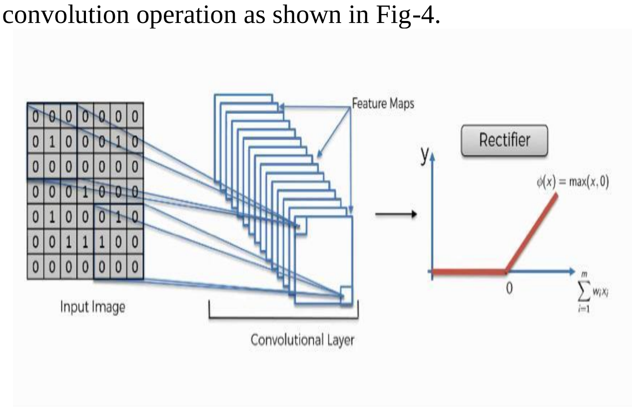

Fig-4. ReLU Activation Function

As the name flattening implies, the pooled feature map is flattened into a column vector as shown in Fig-5.

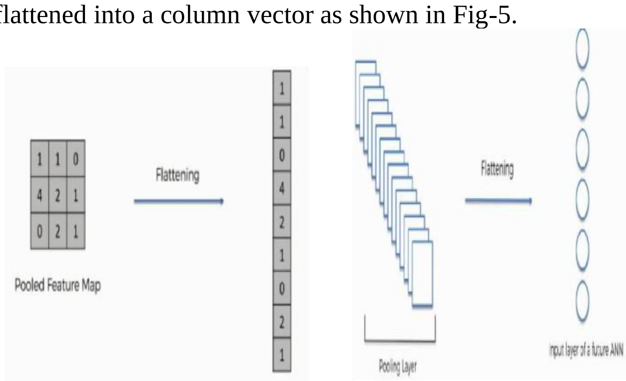

Fig-5. Flattening Layer

The artificial neural networks take the features that were distilled through previous steps & encoded in the form of a vector and combine them into a wide variety of attributes that enables the convolutional neural network to classifying images as shown in Fig-6.

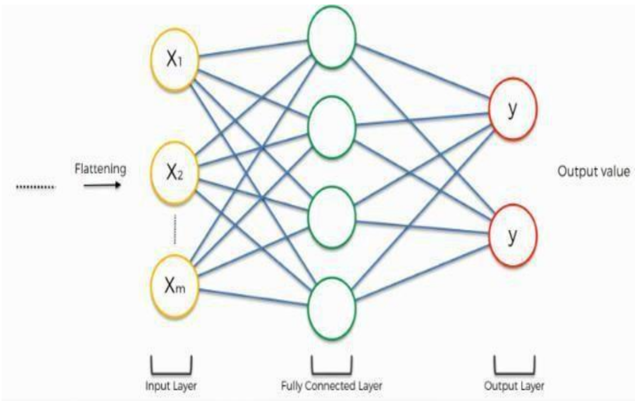

Fig-6. Fully connected Layer

VGG-16 is a kind of convolutional neural network trained on over one million images from the ImageNet database [11]. The network consists of 16 deep layers as shown in Fig-7 and can classify of 1000 different categories, such as mouse, keyboard, pencil, and animals which resulted in network to learn great feature representations for a wide variety of images. The input image size of network is 224 x 224.

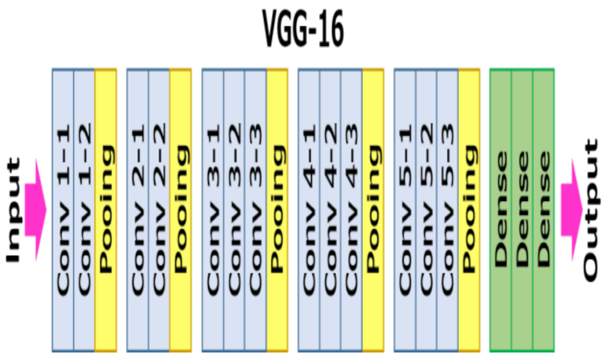

Fig-7. VGG-16 Architecture

CNN and its variants have achieved skillful performance in medical image analysis.

III. DATASET

The proposed methodology is experimented with the data collected from 40 patients which is categorized as 25 patients having heart dysfunctionality and 15 patients not having heart dysfunctionality.

IV. PROPOSED METHOD

The following chain of steps are to be considered for effective recognition of dysfunctionalities in heart by iris as shown in Fig-8.

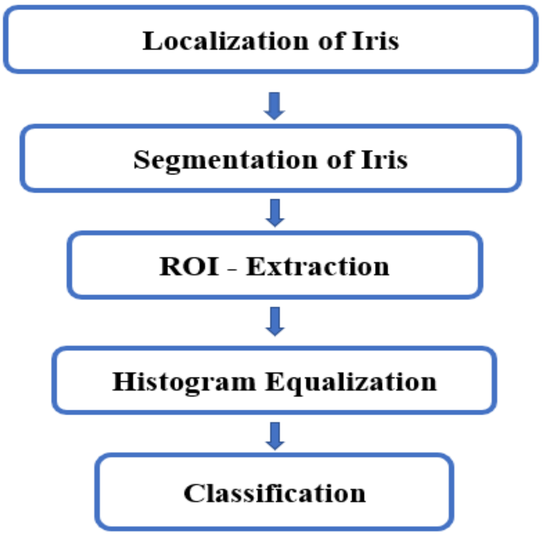

Fig-8. Flow chart of system

A. LOCALIZATION OF IRIS

Localization of iris is the process of finding the boundaries of inner sclera and outer iris for detecting the iris outer boundary. Daugman (1993) proposed a circular edge detection operator for non-concentric circle, as the pupil, iris and sclera are non-concentric circles, the circular edge detection can be used to detect the outer boundary of iris and inner boundary of sclera using,

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

The localized iris using circular edge detection is as shown in Fig-9.

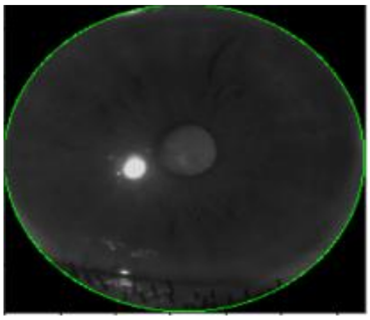

Fig-9. Localized Iris

B. SEGMENTATION OF IRIS

Segmentation of iris is the process of pixel by pixel classification of iris from pupil. The circle Hough Transform is a feature extraction method used in image processing for circles detection in faulty images, as the iris and pupil are non-concentric circles the CHT method can be used for segmenting iris from pupil using,

$$x_c^2 + y_c^2 - r^2 = 0 \qquad (2)$$

Where x_c and y_c are center coordinates and r is the radius which can define any circle, with these centre and radius values, the iris region is segmented which is shown in Fig-10.

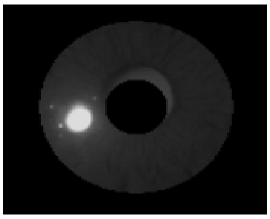

Fig-10. Segmented Iris

C. ROI – EXTRACTION

ROI – Extraction is the process of extracting region of interest viz., heart region from the segmented iris as shown in Fig-11. The heart region is located at clockwise direction between 2:00 to 3:00.

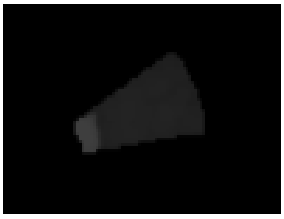

Fig-11. Extracted ROI

D. HISTOGRAM EQUALIZATION OF ROI

Histogram Equalization is a image processing techniques that is used to enhance intensity of image. This can be accomplished by spreading the frequent intensities, i.e. extending the image intensity range. This results in increase of global contrast of an image which makes the areas in the image with lower local contrast region to attain a higher contrast. The Extracted ROI is intensified with histogram equalization for accurate identification of features using,

$p(\gamma_j)=n_j/n$, j=0, 1, 2, 3, 4 ……, 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)

$S_k \Leftarrow (L-1)*S_l$ (5)

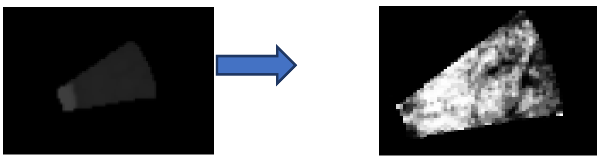

Fig-12. ROI Transformation from Low Contrast to High contrast

E. CLASSIFICATION

The proposed methodology uses the following convolutional neural network architecture for classification:

1) Input: 224 x 224 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 32, stride 1
6) ReLU: max (0, hθ (x))
7) Pool: size 2 x 2, stride 1
8) Conv2D: size 5 x 5, filters 64, stride 1
9) ReLU: max (0, hθ (x))
10) Pool: size 2 x 2, stride 1
11) FC: 256 hidden neurons
12) Dropout: p = 0.5
13) FC: 2 Output Classes

The proposed architecture comprises of 5 hidden layers with 3 Conv2D layers with (32, 32, 64) units having (3x3, 5x5, 5x5) kernel sizes with pooling size 2x2 each, 1 fully connection layer having 256 units, drop out of 0.5 and another fully connection layer having 2 units for output classes. The activation function is used in all the above layers is ReLU, which is given as,

$$f\big(h_\theta(x)\big) = h_\theta(x)^+ = Max\big(0, h_\theta(x)\big) \quad (6)$$

V. EXPERIMENTATION

For carrying out the experimentation with the proposed model based on convolutional neural network presented in section II of the article, the training of the neural network is carried out using the dataset presented in section III of the article. The image is acquired using slitlamp device and is pre-processed and passed onto the CNN for classification to find whether the image belongs to a class having heart dysfunctionality or not as presented in section IV of the article.

The overall experimentation is carried out using Anaconda keras environment with tensorflow backend and the obtained results are evaluated using various evaluation metrics presented in section VI of the article. The obtained results are compared with the VGG – 16 neural network architecture.

VI. EVALUATION METRICS & EXPERIMENTATION RESULTS

For evaluating the performance of the proposed model, different evaluation metrics such as precision, recall, f – score & accuracy are considered.

Accuracy is a measure of percentage of data that is correctly classified by the classifier and is given by,

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \quad (7)$$

Precision measures the exactness as what percentage of data is labelled as positive are actually such and is given by,

$$\text{Precision} = \frac{TP}{TP + FP} \quad (8)$$

Recall measures the completeness as what percentage of positive data is labelled as such and is given by,

$$\text{Recall} = \frac{TP}{TP + FN} \quad (9)$$

The harmonic mean of recall and precision gives F-score which lies in the range of [0, 1] and is given by,

$$\text{F – Score} = \frac{2*Precision*Recall}{Precision+Recall} \quad (10)$$

Where,

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TP: Total no. of images correctly classified as abnormality.
FP: Total no. of images incorrectly classified as abnormality
TN: Total no. of images correctly classified as no-abnormality.
FN: Total no. of images incorrectly classified as no-abnormality.

Table 1: Results of VGG-16 and CNN Models

Metrics / Methods	VGG-16	CNN
Precision	92	95
Recall	60	75
F - score	75	86
Accuracy	60	80

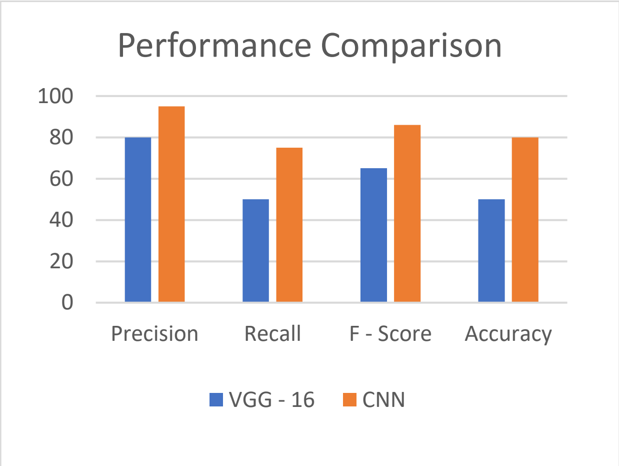

Fig-13. Performance Comparison of VGG-16 and CNN

VII. CONCLUSION & FUTURE WORK

In this article, we have proposed a deep neural network-based methodology presented in section IV of the article, and compared the experimented results presented in section VI of the article with the VGG – 16 architecture performance on the dataset presented in section III of the article. The obtained results stated that the proposed CNN architecture has performed better than the VGG – 16 architecture and attained an accuracy of 80%. Also, the results showcased that better performance can be obtained using 5 layers instead using 16 layered VGG – 16 architecture. The future scope of the proposed model can be extended for other organs abnormality detection in human body based on iridology.

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