Anomaly detection of fundus images

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Abstract. Research states that at least 2.2 billion people have a vision impairment or blindness all over the world. There are many reasons for blindness and few of them are leading causes such as cataract, macular degeneration due to age factor, glaucoma, diabetic retinopathy, corneal opacity, trachoma. In all of them, glaucoma is one of the main causes of blindness. Glaucoma is asymptomatic and non-reversible vision loss disease. This paper presents a method of early detection of glaucoma using deep Neural Network (NN) from the retinal images. In different retinal imaging modalities, fundus images are widely accepted. In deep learning, Convolution Neural Network (CNN) is used for feature extraction from the fundus image, and fully connected feed forward NN (FFNN) is used to find out the level of glaucoma. Typical image processing algorithms are used for feature extraction from fundus images and classified with FFNN. The accuracy is compared among different architectures. The TensorFlow software tool and python language are used for this research.

1. Introduction

Nowadays, science& technology has improved a lot and it plays an important role in the medical department also. As the world is moving, the count of diseases also increased, and eye diseases are also one of them. It is important to detect the diseases in an early stage. This paper introduces different ways comparatively for early detection of glaucoma using neural networks [10]. If India is considered, we find a low doctor to patient ratio and this is the same situation in many countries. Because of this kind of situation, it is important to diagnose diseases at an early stage automatically. Many institutes are working on gathering data from various patients. This data is needed to be analyzed & used properly. This paper gives an idea of fundus image datasets, preprocessing, and analysis, which are used in this process.

2. Model description

2.1. Overview

Neural networking became a powerful tool for training models & finding diseases at an early stage. Glaucoma is such a disease in which damage to the optic nerve leads to progressive, irreversible vision loss. For detection fundus images of the eye are used [7]. This paper is subdivided according to the classification and segmentation task. The tasks are OD, OC segmentation, calculating Cup to Disk ratio (CDR), train module using CNN network. In this paper two methodologies are used for analysis

one is CNN architecture without segmentation another one is segmentation & then CNN architecture. There are many ways to detect glaucoma in terms of feature extraction and use of dataset. For finding CDR value optic nerve head is also used as one of the features [12].

2.2 Methodology

This paper follows the below mentioned methodology as figure 1 and figure 2. This paper includes two methodologies to predict disease. In the first proposed methodology manual process is accepted to find optical cup to disk ratio. As dataset contains annotated fundus images. In second method CDR value is calculated after segmentation of images. The segmentation is done by using thresholding algorithm.

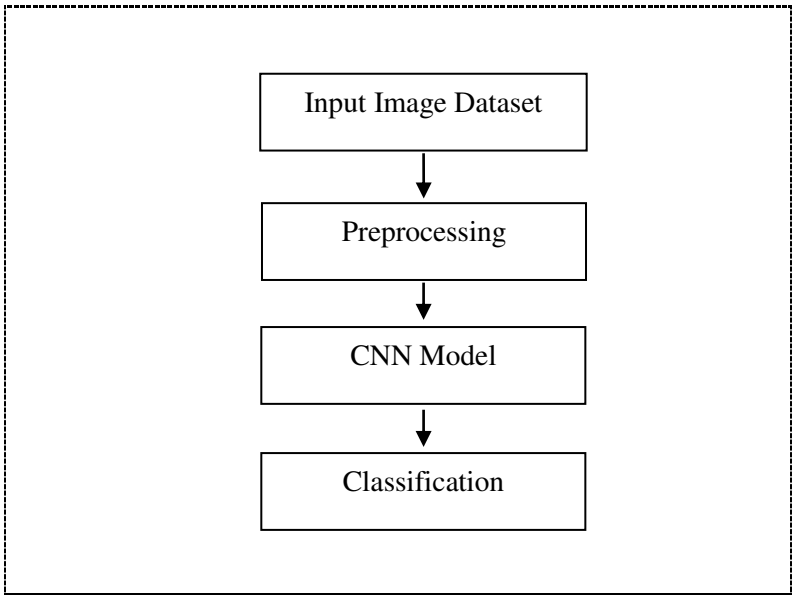

Figure 1. Adiabatic Switching Principle

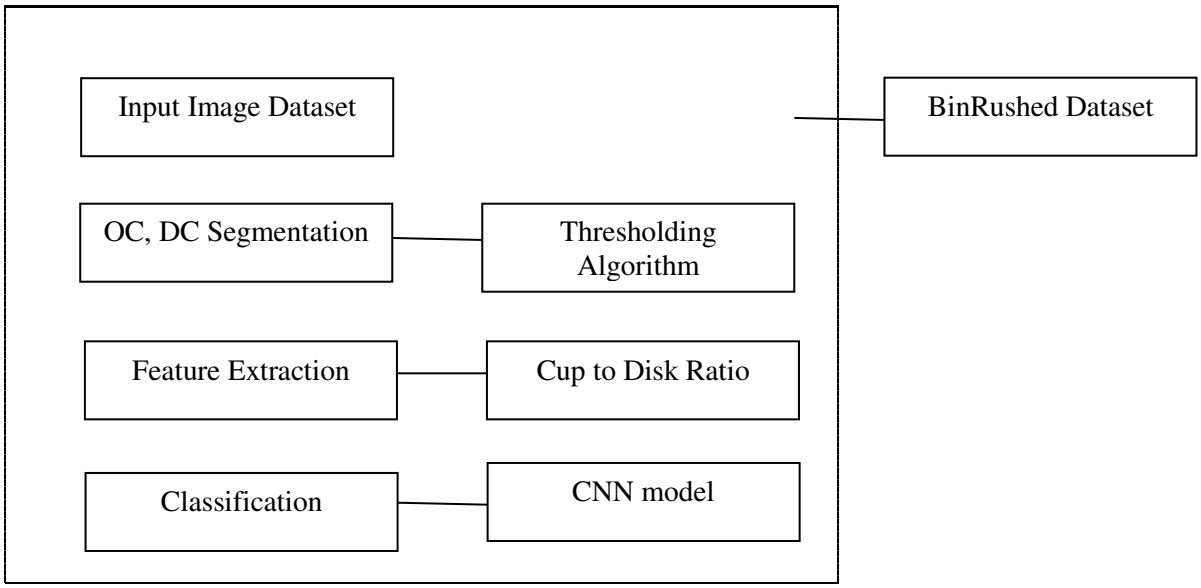

Figure 2. This figure shows CNN Model with Segmentation.

3. Description

3.1. Image acquisition

This dataset has 3 different files: 1. Messidor dataset 2. BinRushed dataset 3. Magrabi Eye center. In this paper, BinRushed dataset is used which includes 195 original fundus images. There are total 1365 images as every original image is manually annotated by six experts. This is not an identified dataset of retinal fundus images for glaucoma analysis. These datasets are public and available for research.

3.2. *Convolution Neural Network (CNN)*

A convolutional network is one of the useful models that give hierarchies of features. CNN is a fully connected network. CNN's belongs to end trainable method [2].

In recent years, CNN's been successfully applied to complex tasks such as segmentation, object detection, image generation.

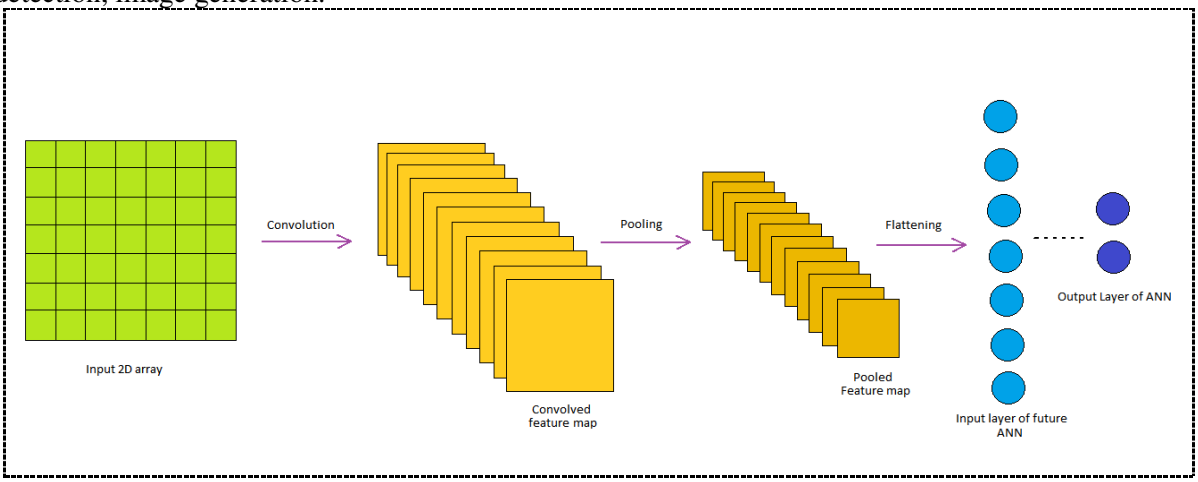

Figure 3. Basic CNN Architecture.

3.3. CNN model without segmentation

In this method images from the dataset are used directly for training & testing. Here CNN network is applied but the required data is manually divided. The dataset is having a total of 195 original images. In this dataset, images are with the marking of optic disk and optic cup which is done by six different experts. Using that information, it is manually separated. This data is applied to CNN architecture and accuracy is obtained [15].

3.4. CNN model and segmentation

The mentioned approach is described by following steps:

3.4.*1. Step 1: Preprocessing.* Before going further, image preprocessing is required. Image preprocessing involves reshape images, create the dataset in the required form, image labeling, etc [10]. These images are labeled manually as required for further processing.

3.4.2. Step 2: Segmentation. Separation of required data for further processing is segmentation. Image segmentation is termed as the partitioning or division of pixels of interest for successful processing [5]. The main purpose of image segmentation is to segment the meaningful regions of interest for processing. Region of interest involves a group of pixels characterized with a threshold value and these may contribute to distinct shapes such as circle, ellipse, polygon, or irregular shapes [14]. The process of segmentation does not give information about the entire image, it incorporates pixel data of only the

region of interest. Segmentation is a crucial process in image analysis because it decides the direction for further analysis.

There are different methods to perform segmentation [1]. In this method, segmentation is done by thresholding algorithm [8]. In the thresholding algorithm, the threshold value is selected according to mean value and standard value for each separate image. After the application of the CNN model for correct analysis fine-tuning is used [6].

3.4.3. Step 3: Cup to Disc Ratio. In the diagnosis of glaucoma, there are many features to detect visually challenged disease Glaucoma but measurement of the optical cup to the optical disk ratio is an important factor. After the segmentation of fundus images, the diameter of the optic cup & optic disk is measured by using the concept of active contours. Active contours approach is used to detect the region of interest (ROI). Activating contours specifies the boundaries of optical cup and optical disk. Diameter of optical cup and optical disk is measured [9]. This optic cup to disk ratio classifies the patient into with glaucoma &without glaucoma. The cup-to-disc ratio for a normal patient is less than 0.5. A large cup-to-disc ratio implies that it is glaucoma extracted feature for detecting glaucoma [11].

3.4.4. Step 4: Classification. A five layers CNN network with 3 convolutional layers with filter size (64, 32, 32) followed by 2 dense layers is used in architecture. The sigmoid function is used as an activation function. In classification, the data set is classified into two classes.

4. RESULTS

4.1. *CNN model without segmentation*

In this method, images are classified manually and then trained with CNN model. Dataset is trained using a Convolution neural network.

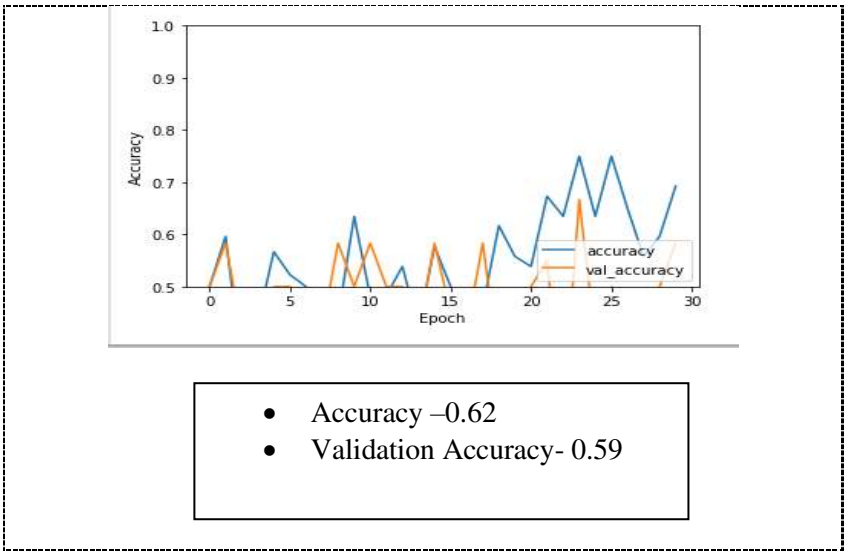

Figure 4. Evaluation Model of CNN Network with Segmentation.

4.2. CNN model and segmentation

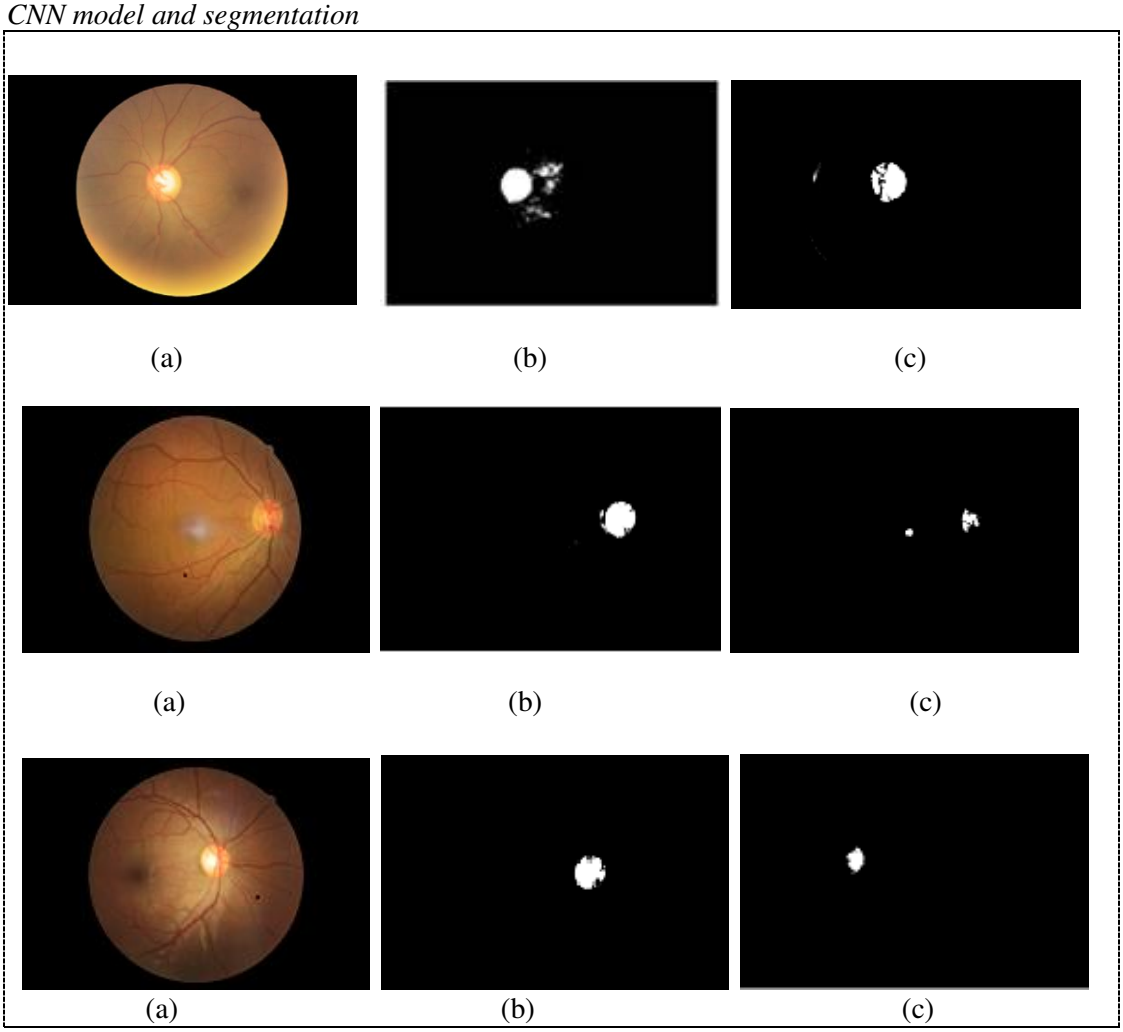

Figure 5. These figures show results of segmentation done by thresholding algorithm. figure 5 segmentation results show (a), (b), (c) are columns of the images after segmentation. (a) Original image, (b) Segmented Optical disk, (c) Segmented Optical cup.

Table 1. This table shows few examples of cup to disk ratio.

Images	Cup to Disk Ratio (CDR)
Image 1	0.625635
Image 2	0.383789
Image 3	0.5
Image 4	0.733728
Image 5	0.484881

As shown in table 1, cup to disk ratio is an important aspect of detecting glaucoma. For detecting CDR ratio active contours approach is used. Using these ratios glaucoma disease is detected and possible to detect in early stage also. For segmentation task 195 original fundus images.

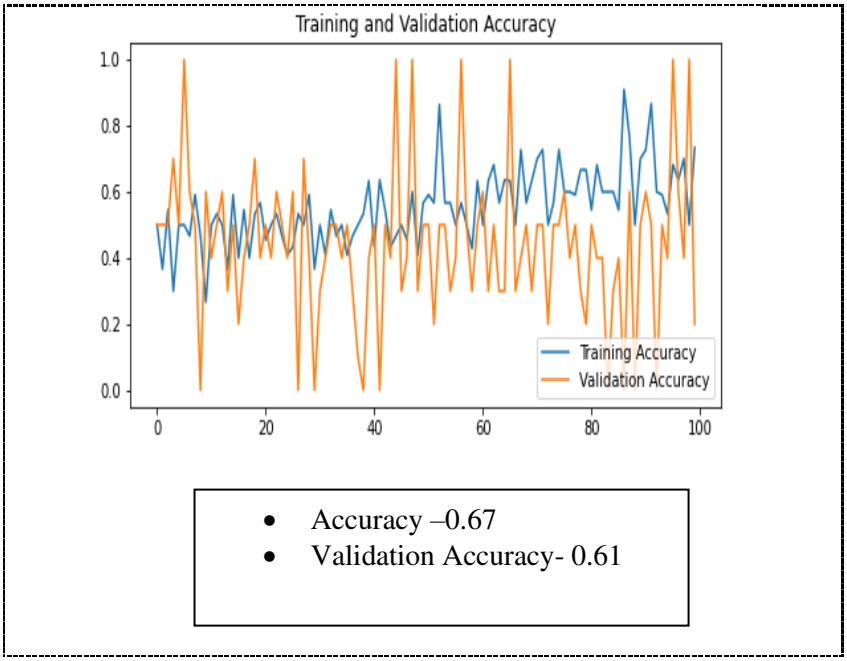

Figure 6. Evaluation model for CNN network with Segmentation

5. Conclusion

The mentioned technology will be especially useful in the perspective of the medical field. In this paper, different methods are used for detecting Glaucoma and to train module. This paper gives a comparative analysis for detecting Glaucoma. This involves the segmentation process, the active contour model, application of the CNN model. Our experiment results give analysis that training dataset after segmentation gives better results than manual method. This paper highlights the importance & the use of neural networks in the medical field to detect diseases like glaucoma in the early stage.

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