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# Detection of Hypertensive Retinopathy in Rural Areas

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***Abstract:***
*Hypertensive retinopathy is one of the most common eye disease found in the rural areas which usually go unnoticed and most of the time untreated for patients in remote areas with no easy access to eye hospital.*
*In this paper, a method is proposed in which Hypertensive retinopathy can be easily diagnosed and patients can be informed about their medical condition and they are advised to take further treatment if necessary. It is done with the help of a simple 20D lens and a mobile phone with a good camera resolution. This method is highly efficient in the remote areas wherein the high cost and heavy retinal defect detection equipment cannot be implemented. Hence simple and low cost equipment can be used for the detection of Hypertensive retinopathy.*

***Keywords:*** *Hypertensive retinopathy(HR), 20D lens*

## 1. Introduction

Hypertension (also known as High blood pressure) is a long term medical condition, in which the pressure of the blood flowing in the arteries is elevated persistently. There are a number of risk factors which go hand-in-hand with High blood pressure, they are coronary artery disease, stroke, heart failure, peripheral vascular disease, vision loss and chronic kidney disease.
Hypertension causes damage to the blood vessels in the retina (the area at the back of the eye) where the image of the object being viewed is focused. Hypertensive retinopathy is a clinical retinal disorder of the eye which causes the abnormality in the image formation in the retina leading to blindness at the final stage. Hypertensive retinopathy can be discovered only through routine eye examination. Symptoms might include headaches and vision problems.
The first step of our examination includes testing. The patient is examined with the help of a sphygmomanometer to check whether he/she suffers from High blood pressure. If yes, then such patients are at a high risk of being the victims of Hypertensive retinopathy and hence they will be suggested for further testing for conformance of Hypertensive retinopathy.
The second step includes capturing the image of the retina of the eye with the help of a mobile phone camera which captures the fundus images using the 20D lens.
The third step includes pushing the images onto the web service hosted on the cloud. Algorithms present on the cloud compares the images being pushed with the images present in the cloud repository and classify the Hypertensive retinopathy into different grades (grade0 to grade 4). A result is obtained as to which grade the particular patient belongs to.
The results can further be sent to the physicians across the world and the patients screened positive for Hypertensive retinopathy are advised for more diagnosis.
Thus, a doctor in rural area without any sophisticated high end medical equipment can detect and ensure that their diagnosis is accurate and enhance quality of the treatment so that the treatment is in line with the diagnosis. The doctor can also obtain second opinion If required from doctors around the world without the requiring the patients to go anywhere else.

## 2. Literature Review

The anatomical complexity of the eye and different grades in the Hypertensive retinopathy make its detection a very challenging process.
Hypertensive retinopathy can be classified into various grades based on their anatomical changes and symptoms. Their classification is given as below:
The grade-1 of Hypertensive retinopathy shows the signs of barely detectable arterial narrowing along with the symptoms of mild hypertension.
The grade-2 of Hypertensive retinopathy shows the obvious signs of arterial narrowing along with the focal irregularities of the images formed at the back of the eye.

The grade-3 shows the obvious signs of Hypertensive retinopathy which includes 1) Retinal hemorrhage, they are red spots which refer to blood stained regions that are caused by bleeding of the retina. 2) Cotton wool spots, they are hazy whitish yellow regions that are caused by damage to the nerve fibers. 3) Exudates, they are bright yellow spots which are indicative of concentrated fat deposits in the retina that in turn lead to blood clots and spillage.
The grade-4 shows the final stage of Hypertensive retinopathy which includes Papilledema, which is optic disk swelling that is caused by increased intracranial pressure. The swelling is usually bilateral and can occur over a period of hours/weeks.

| Grades | Anatomical changes | Symptoms |
|---|---|---|
| **Grade-1** | Barely detectable arterial narrowing. | Mild hypertension.<br>No other symptom. |
| **Grade-2** | Obvious arterial narrowing with focal irregularities like myopia or hypermetropia. | Slight deterioration of vision. |
| **Grade-3** | Anatomical changes of grade-2 +Retinal hemorrhages, excudates, cotton wool spots, Retinal edema. | Actual Hypertensive retinopathy. |
| **Grade-4** | Anatomical changes of grade-3 + papilledema | Reduced survival and require immediate treatments. |

*Table 1*

**3. Proposed Method**

Fig 1 shows the block diagram of the proposed method of diagnosing Hypertensive retinopathy. The first step includes the examination of a person for Hypertension using a sphygmomanometer by a doctor. If the person is found to be Hypertensive, then such patients are further sent for screening of the Retina for the detection of Hypertensive Retinopathy. This is done with the help of a 20D lens which is very beneficial for taking the retinal fundus images and a mobile phone camera.
The images thus taken are pushed onto a cloud in which the data segregation algorithm is present. The RGB images thus sent are converted to gray scale images and are compared to the already present reference gray scale images in the cloud repository. The cloud repository consists of a bundle of gray scale images separately mapping to each grade of the Hypertensive retinopathy. A certain tolerance value is set between the comparison of images. If the image sent using the cell phone matches any of the image present in the repository by 80%, the image is considered to be belonging to that particular grade. If an image matches more than one image or a couple of images in the repository, then the image which is most accurate to the image present in the repository is considered to be the closest match and it can be concluded that the image belongs to that particular grade. Here, the MATLAB software may be used for the conversion of RGB image to grayscale image, for the process of automatic registration of the images and also for the comparison of the two grayscale images.
The function in MATLAB software that supports RGB to gray conversion if "rgb2gray". The function rgb2gray converts the true color image RGB to the grayscale intensity image I. The rgb2gray function converts RGB images to grayscale by eliminating the hue and saturation information while retaining the luminance. The function "imregister" of MATLAB can be used for the process of auto registration, imregister can be used to automatically align two grayscale images to a common coordinate system using intensity-based image registration. The function "imshowpair" of MATLAB can be used to compare the differences between the two grayscale images. The function imshowpair(A,B) creates a visualization of the differences between images A and B. If A and B are different sizes, imshowpair pads the smaller dimensions with zeros on the bottom and right edges so that the two images are the same size, imshowpair returns object, an image object.
Once the comparison has been made, the obtained result is returned to the doctor on his cell phone as to which grade of Hypertensive retinopathy the patient belongs to. Based on which the further treatment needed by the patient can be given by the rural doctor or he may be advised for further diagnosis or treatment in a hospital which offer better facilities. The images can also be sent for doctors around the world and second opinion if required can be obtained for the obtained results.

*3.1. Detection of Arterial Narrowing*

In gray scale images, we use the location of each pixel that is identified with spatial co-ordinate and each has a fixed value. A method was proposed was in paper 'Retinal image analysis: Concepts, applications and potential' for the detection of arterial narrowing. In that method, they make use of an intensity profile line crossing perpendicular to the blood vessels to produce distinct Gaussian distribution curve. This line will tend to produce a contrast against a background retinal surrounding. The Gaussian model can be analyzed using image processing. The width of the arterial vessels can be calculated using the formula,

$F(x) = P_1 * e^{-((x-P_2)/P_3)^2} + P_4$

Where, $P_1$ = Amplitude of peak of profile

$P_2$ = Position of peak

$P_3$ = Parameter of Gaussian function which controls the width of the profile

$P_4$ = Background retinal intensity

The above formula can be used for the detection of arterial narrowing which constitutes to the grade 1 and grade 2 of the arterial narrowing. Barely detectable arterial narrowing constitutes to grade 1 of Hypertensive retinopathy. The greater arterial narrowing above a certain threshold value along with focal irregularities constitutes to grade 2 of Hypertensive retinopathy.

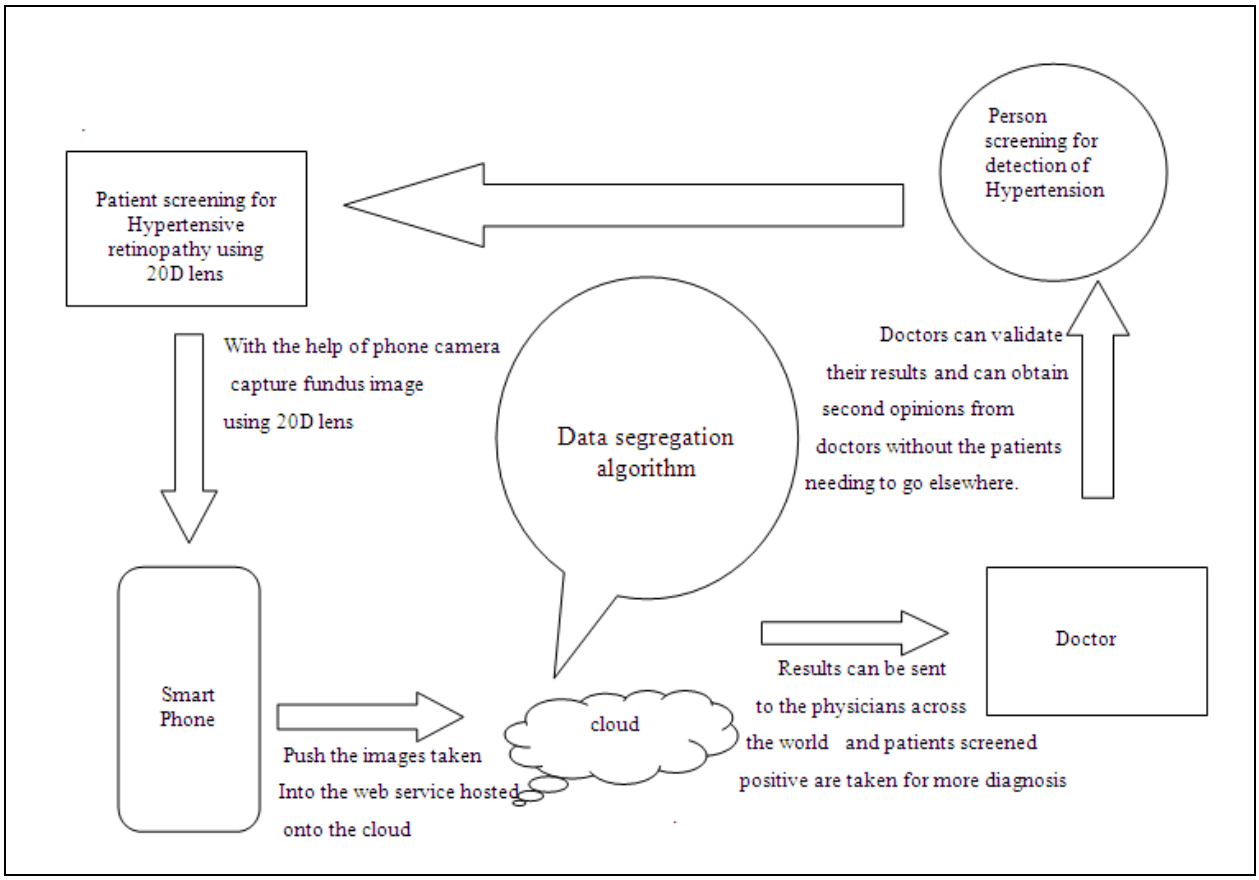


*Figure 1: Diagnosis of hypertensive retinopathy in rural areas*

*3.2. Detection of Retinal Hammorages, Exudates, Cotton Wool Spots and Retinal Edema*

A common methodology namely 'Key-point matching technique' may be used for the detection of Retinal hemorrhages, Exudates, Cotton wool and Retinal edema which constitute to the grade 3 of Hypertensive retinopathy. The main goal of key point matching technique is to compare the two images, that is image A is compared with image B

$$A(i, j) = B(i, j)$$

Where i, j are the x and y co-ordinates of the image.

It can be obtained by the pixel to pixel comparison of the gray scale image. If A (i, j) == B (i, j), then the result will be proven to be 100% accurate, which is seldom possible when it comes to comparison of two medical images and also taking into account that the images are taken using a mobile phone by a person manually. A certain tolerance level needs to be set for these images, that is 0.2 or we can look for images that are 80% accurate. If A (i, j) – B (i, j) <= tolerance (0.2), then the images are said. This way the image can be classifies into different grades based on which particular images it most closely matches to and to which grade the image which is compared in the repository belongs to.

*3.3. Detection of Papilledema*

The method implemented for the detection of arterial narrowing can also be implemented for the detection of Papilledema. Here, the only difference is that the swelling of the optic disk can be observed. The same formula can be used to compare the optic disk with between the two images.

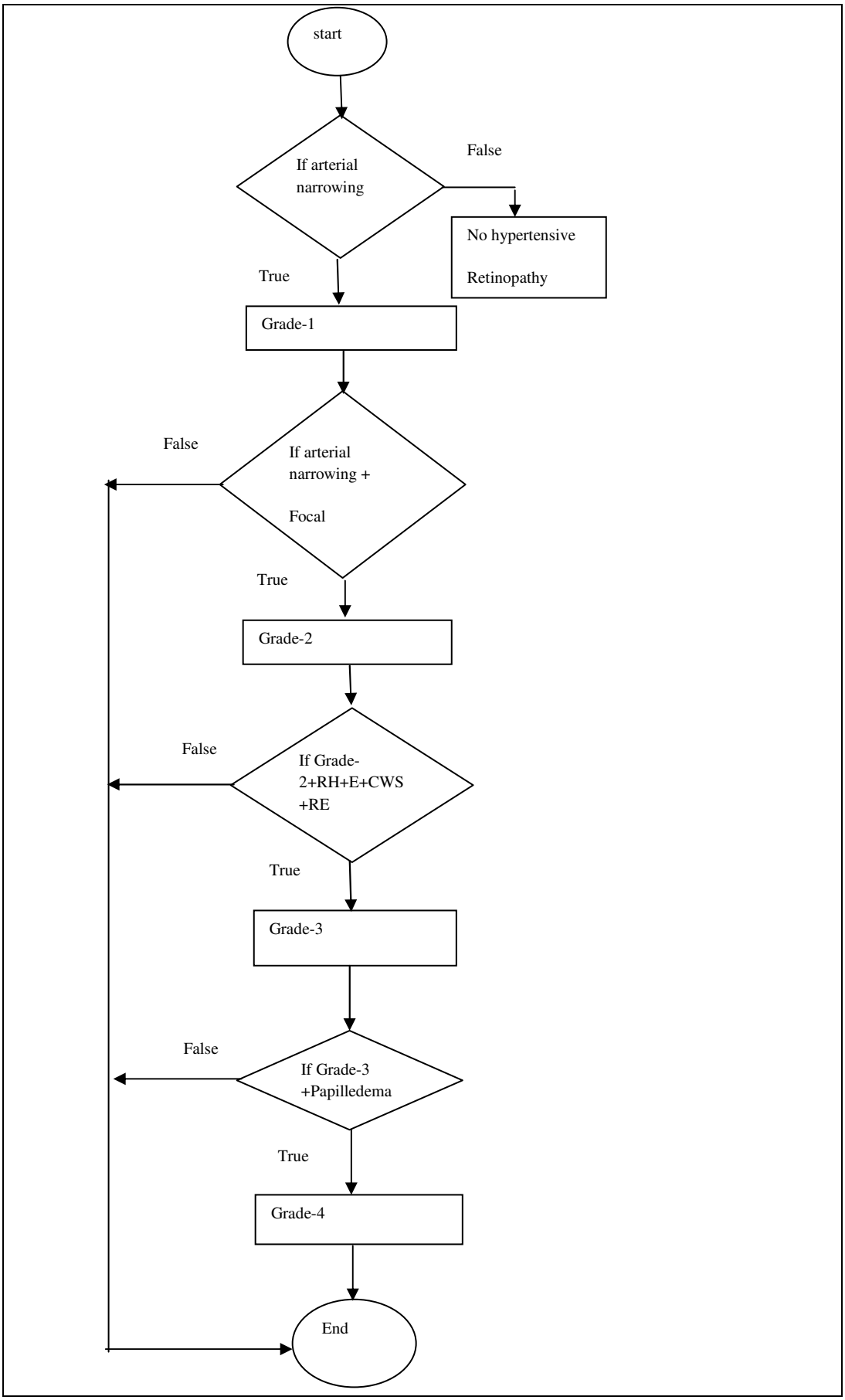


*Figure 2: Flow Chart*

The fig.2 illustrates the flow chart of the Hypertensive Retinopathy which gives us a better understanding about the concept of Hypertensive retinopathy.

**4. Conclusion**

The proposed method is an idea which can be implemented and used in remote rural areas for the screening of the Hypertensive retinopathy. This method may prove to be beneficial to areas wherein the deployment of costly and sophisticated machines for screening of Hypertensive retinopathy is not possible.

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