RETINAL IMAGE ANALYSIS FOR EVALUATING IMAGE SUITABILITY FOR MEDICAL DIAGNOSIS

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ABSTRACT

The quality of a retinal image is assessed using the algorithm based on image quality indicators is introduced. Features such as colour and focus are used as quality indicators and are computed using novel image processing techniques. These quality indicators are also classified to evaluate the image suitability for diagnosis purposes. The retinal images are collected from DRIVE, ROC and STARE datasets. Artificial feed forward neural network classifier is used to classify the retinal image and simulated using MATLAB.

Keywords–Artificial Neural Network, Colour Index, Colour Measure, Focus Measure, Retinal Image Quality.

I INTRODUCTION

Eye diseases such as diabetic retinopathy and age-related macular degeneration affect a considerably large share of the population and its prevalence is expected to increase in the near future. Diabetic retinopathy is damage to the retina caused by complications of diabetes, which can eventually lead to blindness. Diabetic retinopathy may cause vision loss more rapidly, may not have any warning signs for some time. In general, however, a person with macular edema is likely to have blurred vision, making it hard to do things like read or drive. Glaucoma is a term describing a group of ocular (eye) disorders resulting in optic nerve damage or loss to the field of vision, typically caused by a clinically characterized pressure build-up in regards to the fluid of the eye (intraocular pressure-associated optic neuropathy).The disorders can be roughly divided into two main categories, "open-angle" and "closed-angle"(or "angle closure") glaucoma. The angle refers to the area between the iris and cornea, through which fluid must flow to escape via the trabecular meshwork, an area of tissue in the eye located around the base of the cornea.

AMD is a common eye condition and a leading cause of vision loss among people age 60 and older. It causes damage to the macula, a small spot near the centre of the retina and the part of the eye needed for sharp, central vision, which lets us see objects that are straight ahead. In some people, AMD advances so slowly that vision loss does not occur for a long time. The eye care professional will look at the retina for early signs of the disease, such as: Leaking blood vessels, Retinal swelling, such as macular edema, Pale, fatty deposits on the retina (exudates) – signs of leaking blood vessels, damaged nerve tissue (neuropathy) and any changes in the blood vessels. If macular edema is suspected, FFA and sometimes OCT may be performed. Poor quality images may be caused by cataract, poor dilation, ptosis, external ocular condition, or learning difficulties. There may be artifacts caused by dust, dirt, condensation, or smudge.

Commonly, in order to screen for and diagnose retina related conditions, digital fundus photography is used, which enables a non-invasive examination and allows image storage and transmission for later use at different locations. However, in all cases the resulting digital retinal images must be examined by an expert human grader, usually a trained ophthalmologist or optometrist, which makes the whole process very difficult and time consuming, a problem aggravated by the scarcity of specialized human resources. Moreover, both DR and AMD are diagnosable, based on well known and perfectly characterized symptoms which are detectable by visual inspection of the eye fundus, and may be treatable if detected at an early stage.

The use of automated evaluation of digital retinal images has the potential to reduce the workload and thus increase the cost-effectiveness of such screening also some manufactures offer automated clinical decision support system targeting these applications including retinal image analysis tool with diagnostic capabilities. However, there still remain a number of problems that must be overcome in order to develop fully reliable automated retinal images analysis systems. One of these problems is the need to guarantee that the quality of the retinal images to be graded exceeds a threshold below which the automated analysis procedures may fail. This is a real problem for low-quality images as seen in [1], [4] so a computationally efficient algorithm for assessment of retinal image quality of very good performance compared to conventional methods is developed.

1.1 Retinal Image Quality

Retinal image quality may be impaired by a number of factors which can degrade a retinal image to the point of rendering it “ungradable”, which by definition is a retinal image with insufficient quality and without signs of disease. The parameters such as focus, clarity, field definition, visibility of the macula, visibility of optical disc and artefacts are very important for the correct evaluation of retinal image quality. The image artefacts are mostly caused by the occurrence of haze, presence of dust and dirt, partial occlusion by eyelashes, improper cleaning of the camera lens, uneven illumination over macula, uneven illumination of the optic disc, uneven illumination of the image edge and the total eye blink. Our work evaluates retinal image quality through classification of features derived from generic image quality parameters.

1.2 Previous Works on Image Quality Assessment

Image focus is evaluated based on the analysis of the global distribution of edge magnitudes in the image and on local analysis of intensity distribution [8]. [2] Focused their quality assessment algorithm on image sharpness and illumination. Illumination quality measured through evaluation of retinal image contrast and brightness. [3] Evaluated the image along the dimensions of colour, luminance and contrast, achieving an overall sensitivity of 100% and specificity of 96%. [5] Proposed a method but focused only on eye vasculature and not on the entire eye structure

II. DESCRIPTION

The retinal image quality assessment algorithm proposed in this work follows a sequence of steps: pre-processing, the generic image attributes of colour and focus are evaluated and classified. During pre-processing useless image information is removed or masked also the image is cropped and then subjected to removal of noise.

2.1 Pre-Processing

Each image is first subjected to a pre-processing phase which removes unimportant information by masking and cropping the image to include only pixels showing retinal data**.** Images are often degraded by noises. Noise can occur during image capture, transmission, etc. So in order to preserve the real image noise should get removed from it. Masking is a technique used to selectively obscure or hold back parts of an image while allowing other parts to show. Cropping an image extracts a rectangular region of interest from the original image. This focuses the viewer's attention on a specific portion of the image and discards areas of the image that contain less useful information. Image cropping allows zooming a specific portion of the image.

2.1.1 Noise

Noise usually quantified by the percentage of pixels which are corrupted. Amplifier Noise (Gaussian noise) is a noise in which each pixel in the image will be changed from its original value by a (usually) small amount. Salt and pepper noise also called impulse noise can be caused by dead pixels, analog-to-digital converter errors and bit errors in transmission. Shot noise is a dominant noise in the lighter parts of an image from an image sensor is typically that caused by statistical quantum fluctuations, that is, variation in the number of photons sensed at a given exposure level; this noise is known as photon shot noise which follows Poisson distribution. Speckle Noise (Multiplicative Noise) While Gaussian noise can be modelled by random values added to an image, speckle noise can be modelled by random values multiplied by pixel values hence it is also called multiplicative noise. Speckle noise is a major problem in some radar applications.

2.1.2 Types of Filters to Remove Noise

Linear smoothing filter is one method to remove noise is by convolving the original image with a mask that represents a low-pass filter or smoothing operation. For example, the Gaussian mask comprises elements determined by a Gaussian function. This convolution brings the value of each pixel into closer harmony with the values of its neighbours. In general, a smoothing filter sets each pixel to the average value, or a weighted average, of itself and its nearby neighbours; the Gaussian filter is just one possible set of weights. Smoothing filters tend to blur an image, because pixel intensity values that are significantly higher or lower than the surrounding neighbourhood would "smear" across the area. Because of this blurring, linear filters are seldom used in practice for noise reduction; they are, however, often used as the basis for nonlinear noise reduction filters. Wiener filters: The wiener function applies a Wiener filter (a type of linear filter) to an image adaptively, tailoring itself to the local image variance. If the variance is large, wiener performs little smoothing. If it is small, wiener performs more smoothing. This approach often produces better results than linear filtering. The adaptive filter is more selective than a comparable linear filter, preserving edges and other high-frequency parts of an image. In addition, there are no design tasks; the wiener2 function handles all preliminary computations and implements the filter for an input image. wiener2, however, does require more computation time than linear filtering. Wiener works best when the noise is constant-power ("white") additive noise, such as Gaussian noise. Median filter is an example of a non-linear filter and, if properly designed, is very good at preserving image detail. To run a median filter: Consider each pixel in the image, Sort the neighbouring pixels into order based upon their intensities, Replace the original value of the pixel with the median value from the list . Fuzzy filters provide promising result in image-processing tasks that cope with some drawbacks of classical filters. Fuzzy filter is capable of dealing with vague and uncertain information. Sometimes, it is required to recover a heavily noise corrupted image where a lot of uncertainties are present.

2.2 Focus Assessment Algorithm

The retinal image focus degree is classified as either ‘‘blurred’’, ‘‘borderline’’ or ‘‘focused’’. The method used in this work is based on image gradient magnitude approaches. Focus is measured through the application of the perwitt operator to the retinal image after conversion to grey scale, followed by a multi-focus-level analysis. The algorithm has three stages. The first stage corresponds to the application of the perwitt operator to the original grey scaled retinal image, and the resulting focus measure (FM1) corresponds to the mean of the respective gradient map of original image. In second stage the grey scaled image is low-pass filtered with a 3 *3 moving average filter, the perwitt operator is applied and the focus information (m2) gathered through the mean of the resulting gradient map of level I defocused image. The second focus measure (FM2) corresponds to the difference between FM1and m2. In the final stage, the original grey scaled image is again low-pass filtered with a 5 *5 moving average filter, the perwitt operator is applied and the focus information (m3) gathered through the mean of the resulting gradient map of level 2 defocused images. The third focus measure (FM3) is obtained through the difference between m2 and m3.

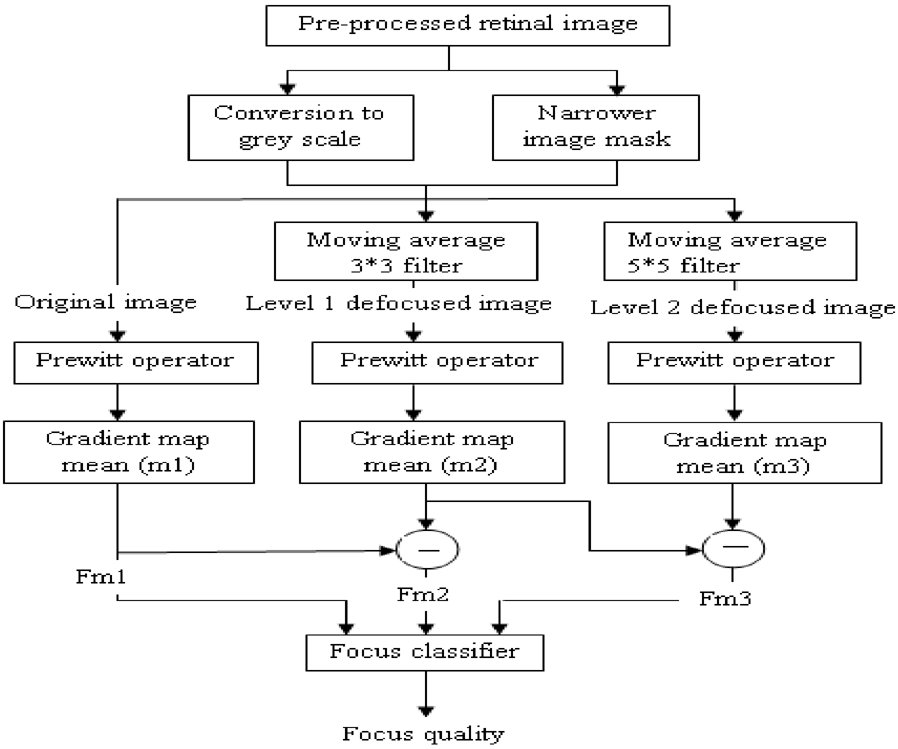


Fig 1 Focus Assessment Algorithm Flowchart

Perwitt operator is used particularly in edge detection algorithm. Technically, it is discrete differentiation operator computing an appropriate gradient of image intensity function. Gradient is measure of change in intensity of some point in original image in given direction. Pixels with large gradient value become possible edge pixels. Edges may be tracked in the direction perpendicular to the gradient direction and used to extract information from images.

2.3 Colour Assessment Algorithm

This algorithm classifies retinal image colour as ‘‘bright’’, ‘‘dark’’ or ‘‘normal. The procedure starts with a colour indexing operation, using histogram backprojection. Histogram backprojection answers the question ‘‘Where in the image are the colours that belong to the object being looked for (the target)?’’ In our case, the object looked for is a colour palette represented by a pre-defined colour map. In our application for each image class a specific colour map was computed from the contents of training images belonging to that class. Accordingly, the ‘‘bright colour map’’, “dark colour map’’ and ‘‘normal colour map’’ are computed. Each of these colour maps is used to perform colour indexing of the retinal image being processed, with the creation of three different indexed images, Then the average values of the three indexed images are computed, yielding three colour measures (CM1, CM2, and CM3). Finally since each image colour class occupies specific regions in the feature space, the image class (‘‘bright’’, ‘‘dark’’ or ‘‘normal’’) can be determined using clustering or classification techniques.

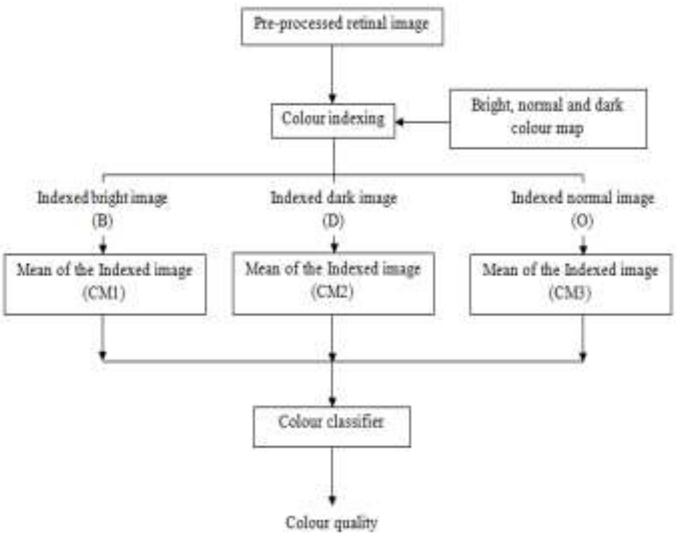
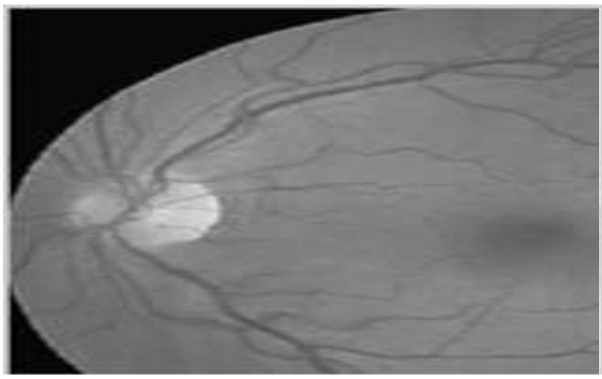


Fig 2 Colour Assessment Algorithm Flowchart

Indexed colour is a technique to manage digital images, colour is displayed in a limited fashion, in order to save computer memory and file storage, while speeding up display refresh and file transfers. It is a form of vector quantization compression. When an image is encoded in this way, colour information is not directly carried by the image pixel data, but is stored in a separate piece of data called a palette: an array of colour elements, in which every element, a colour, is indexed by its position within the array. The image pixels do not contain the full specification of its colour, but only its index in the palette. This technique is sometimes referred as pseudo colour or indirect colours as colour are addressed indirectly. K-means clustering is a method of vector quantization, originally from signal processing, that is popular for cluster analysis in data mining. K-means clustering aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster. This results in a partitioning of the data space into Voronoi cells.

III. RESULTS

Pre-processing the retinal image includes cropping masking and removal of noise from the original image. The figure 3 shows the result for cropped image here the left part of the image is cropped. The figure 4 shows the result for masking an retinal image i.e. sharpening the original image.The figure 5 shows the results for removal of various noise using fuzzy filter.



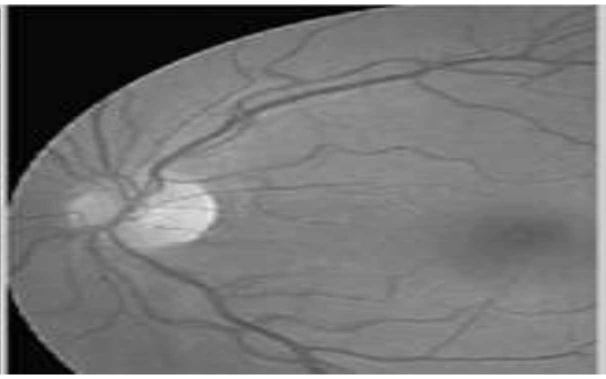


Fig 3 Cropped image **Fig 4 Masked image**

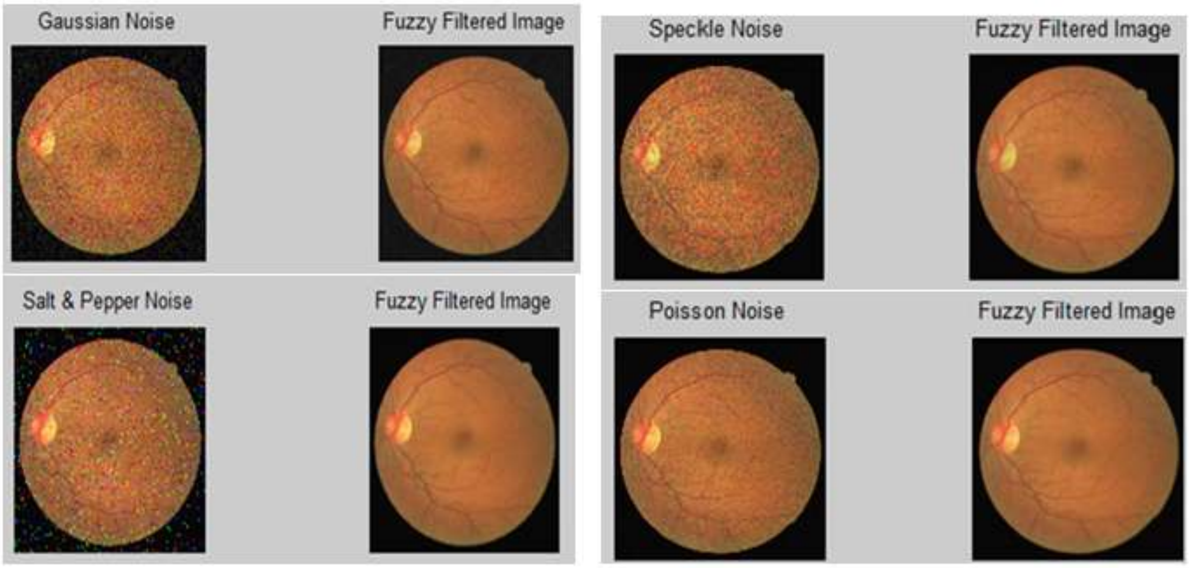


Fig 5 Filtered Image

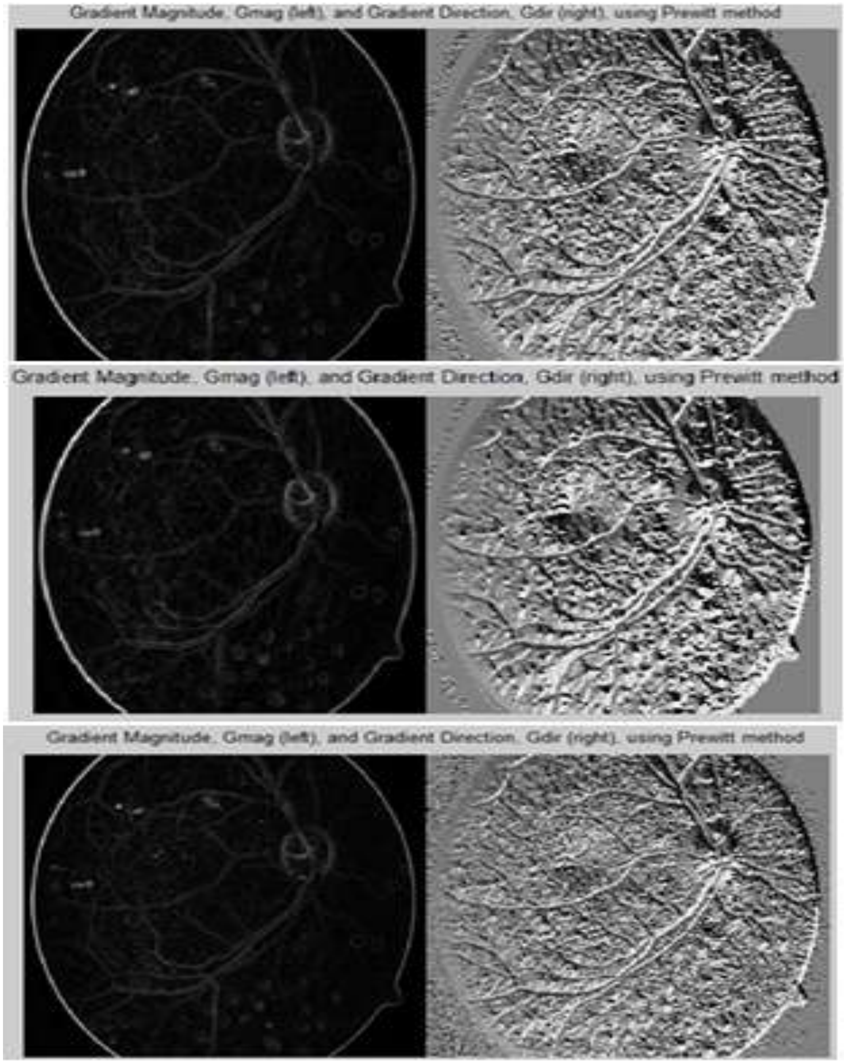
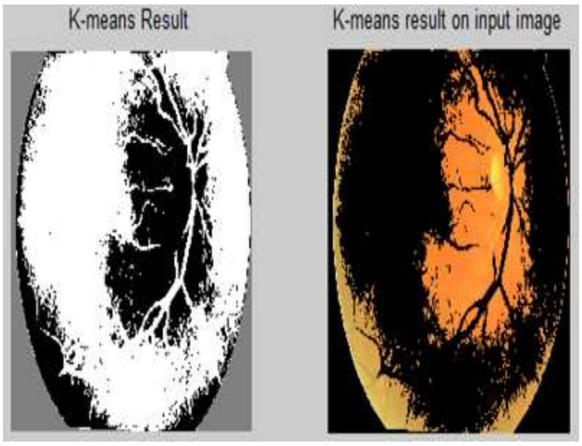


Fig 6 Gradient of original image (top), level 1 defocused image (middle), level 2 defocused image (bottom).

Fig 7 Final result for focus assessment

Figure 6 shows the gradient i.e., magnitude and direction of the original image intensity and image defocused at various levels. Blurred image is given as input which is correctly classified by the neural classifier. Figure 7 here y=0 means blurred image, y=1 means bordered image and y=2 means focused image.

Fig 8 Indexed gray image (top), indexed colour image (bottom)



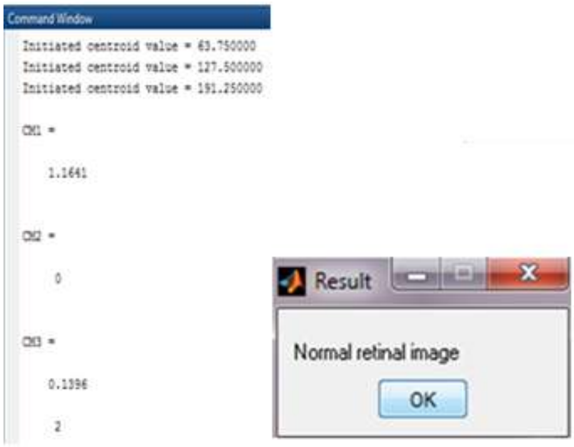


Fig 9 Clustered image **Fig 10 Final results for colour assessment**

Figure 10 shows the final result for colour assessment. The centroid values for dark, bright and normal image is displayed in the command window. Here final value 0 means dark image, 1 means bright image and 2 means normal image.

IV.CONCLUSION

The proposed retinal image quality assessment algorithm relies on the measure of generic image features, namely colour, focus, contrast and illumination computed using specific algorithms. This individual image quality indicators classification is very important as it produces partial image quality indicators which can be used for real time quality assessment. In this work colour assessment and focus assessment are performed separately and the corresponding results have been obtained. In the future work along with colour and focus assessment of retinal image contrast and illumination assessment has to be performed individually. In addition to it all those quality indicators are combined together and classified to assess the image quality. Along with this work performance of the classifier is evaluated by computing sensitivity and specificity.

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