ROLE OF EYE PERCEPTION IN ANALYSIS OF VISION DEFECTS

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Abstract: This paper confers the reasons for color vision defects in human eye. This paper also discusses the design and development system for the people who are having problems in their visual system, such as color blindness, low vision, or visual field defects. A new model has been proposed that examines the color vision, vision field defects and visual acuity. Model has proposed that is working on the perception of the candidate eye. The rule base has been created to receive the image the candidate perceives. Based on the candidate perception the problem that its eye have can be analyzed.

Keywords: Color Vision, Vision Test, Image processing, Visual field defects.

1. INTRODUCTION

Color enriches our understanding of the visual world, providing description and convolution. Most of the early researcher of the phenomenon of color vision did not consider it possible that the visual system could contain a separate mechanism for each of the large number of colors human can distinguish. One of the original color vision theories, the Young-Helmholtz theory, correctly suggested that there were only three different ocular sensors that responded to red, green, and blue light. The eye and color photographic films both analyze colors by responding to their red, green, and blue components, even at the retinal level, information from the three-color channels (three cone types) is combined into an opponent organization.

Human color vision defects are typically associated with the X-chromosome visual pigment genes that is \( \text{L} \) and \( \text{M} \) cone opsin genes. Color vision defects caused by a loss of \( \text{L} \) photopigment and \( \text{M} \) photopigment function. Color vision defects, there are two broad categories—dichromacy and anomalous trichromacy. Anomalous trichromats do not have the normal \( \text{S}, \text{M}, \text{L} \) photopigment. They have three different pigments, but are different from normal. Dichromate bases their vision on an \( \text{S} \) pigment and a single pigment in the \( \text{L/M} \) region of the spectrum. As might be expected, they have very little color discrimination. They distinguish most colors on the basis of saturation and lightness variations alone. Anomalous trichromats have slightly better color discrimination. Monochromats are individuals who are truly “color-blind”, completely lacking functional cone photoreceptors. There are also individuals with function of a single cone type who can achieve minimal color discrimination under certain lighting conditions [13-14].

Human vision is a process of great complexity that involves many processes such as shape and pattern recognition, motion analysis, and color perception. For people get heritage, illness or weakness because of ageing or injured, it comes out the loss of vision sense functions and that create difficulty for them communicate with the outside world. Although there exist ways to help vision defects with various conditions for colorblind and low vision [1], a simple, practical, integrated, and effective one is not available.

In this paper, an image processing based portable system is design and developed which describes some of the problems a human eye can have. Number of mathematical equations and programming concepts has been implemented. Interface is created which will help a person to generate the problems that his eye is having.

The system structure and detailed function descriptions are given in section II. The experimental methods and results are shown in section III, while a short conclusion is given in the last section.

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2. STRUCTURE OF PROPOSED SYSTEM

The structure of the proposed system consists of three units: Visual Test Model, Visual Image processing and Perceived Image Processing. The Visual Test Model consists of different Color Vision, Visual Field Defects and Visual acuity. Visual Image processing consists of Color perception, Central Vision Processing and Peripheral Vision Processing. Processing will be done on perceived image to find the defects which patient eye is having as compared to the Normal vision will also be displayed. Figure 1 shows the structure of the proposed system. All the above mentioned units will be discussed in details in the subsequent sections.

In this experiment we are considering number of questions for color perception for testing. Figure 2 is explaining the method used for color examination in our system. The diseases which we have considered in our system for Color vision are Color Blindness, Astigmatism, Retinal Degeneration, Diabetic Retinopathy etc.

2.1 Vision Test Model

2.1.1 Color Vision

Color vision is an illusion created by the interactions of billions of neurons in our brain. There is no color in the external world; it is created by neural programs and projected onto the outer world we see. It is intimately linked to the perception of form where color facilitates detecting borders of objects. Color is created by utilizing two properties of light, energy and frequency of vibration or wavelength.

Color vision deficiencies are a group of conditions that affect the perception of color. They cause a range of changes in color vision, from mild difficulty with distinguishing shades to a total inability to detect color. These conditions are divided into three major categories: red-green color vision defects, blue-yellow color vision defects, and a complete absence of color vision.

Red-green color vision defects are the most common form of color vision deficiency. Affected individuals have trouble distinguishing between shades of red and green. They see these colors differently than most people and may have trouble naming different hues. Blue-yellow color vision defects, which are rarer, cause problems with differentiating shades of blue and green. These two forms of color vision deficiency disrupt color perception but do not affect visual acuity.

2.1.2 Vision Field Defects Test

A visual field test is a method of measuring an individual’s entire scope of vision, that is, their central and peripheral vision. Visual field testing actually maps the visual fields of each eye individually. The success of visual field test is a one-sided examination means, it is requiring the patient cooperation and right information should be provided by the patient then only these defects can be identified successfully. In the proposed system input is taken by the patient and the disease information is being generated. We have implemented this system for following vision field defects such as – Macular degeneration, Glucoma, Retinitis Pigmentosa.

2.1.3 Visual Acuity

Visual acuity is the eye’s ability to detect fine details and is the quantitative measure of the eye’s ability to see an infocus image at a certain distance. If a person can read letters at 20 feet that are readable at that distance to all people with normal vision, that person’s visual acuity, or “eyesight”, is said to be 20/20. If one can see at 20 ft what a normal person can see at 40 ft, then one has 20/40 vision. Visual acuity can be indicated by contrast sensitivity measured at different spatial frequencies. In our system we have considered Contrast sensitivity function to find out the acuity and simplifying the image.
2.2 Visual Image Processing

2.2.1 Color Perception Processing

Human vision system has the capability of seeing roughly constant colors from object under different illuminations. This inherent ability of color adaptation by adjusting the spectral response and discounting the illuminant changes is known as human color constancy [6, 7]. Human color constancy is linked to chromatic adaptation, wherein our visual system adjusts its sensitivity according to the context of the illuminated scene. However, human color constancy is possible only under a limited range of illuminants [8].

In human’s trichromatic color vision, a set of 3D tristimulus value determines a color signal. The popular RGB color model corresponds most closely to the human vision. Human normal color vision requires three kinds of retinal photoreceptors with peak sensitivity in the large, medium and short wavelengths portions of the visible spectrum. These photoreceptors are called L, M, and S cones respectively. The spectral response of each kind of cone is defined by the specific type of photopigment it contains. [4, 5].

The three photoreceptors in human eye are tuned approximately to red, green, and blue light 564, 533, 437 nm respectively. A similar tuning range is also frequently used in digital camera, for instance 650, 530, 470 nm. The human vision system adjusts cone sensitivity of each channel to achieve chromatic adaptation. Similarly, the color correction of an overall color cast is done by adjusting the RGB channel gains. This model is also referred to as the von Kries hypothesis, first proposed in 1878, that chromatic adaptation is an independent gain regulation of the three cone signals L, M, S, through three different gain coefficients [9, 10].

2.2.2 Central Vision Processing

Central vision describes a person’s field of vision when he is looking straight ahead. The central vision is the most commonly used part of human vision. It allows people to read, see objects in front of them, and perform other daily tasks and routines. The central vision picks out details of objects, providing the brain with feedback and creating a crisp, clear picture in front of the viewer’s eyes. It is also responsible for interpreting colors and shapes of the objects being viewed [11].

2.2.3 Peripheral Vision Processing

Peripheral vision is hard to study in an objective manner, because there is no way to separate the visual detection of the eye from the neural processing of the brain. While the eye can be dissected and examined under a microscope, even if the entirety of the retina is capable of detecting light, that capacity may not be fully utilized or may not be consciously aware within the brain. It is not possible to directly observe what the brain is detecting and comprehending, so research primarily involves perception tests based on reactions of patient to simulated stimuli. This testing is commonly carried out by requesting patient to focus on an object in front of them and then flashing lights at increasing distances away from the center of the visual field, noting the subject’s reactions.

Both types of vision are important for clear sight, but central vision is more important than peripheral vision for day-to-day functioning. If the macula is damaged, the resulting problems and loss of vision are often extreme, whereas damage that affects only peripheral vision is often less severe. If the macula becomes damaged, the person may only be able to see from his peripheral vision. This creates a permanent blind spot in the middle of the field. When the macula is damaged it may begin to break down over time, leading to blindness. It can happen to only one eye or occur in both eyes. Those who smoke and who spend a lot of time outdoors without proper eye protection are at a higher risk of developing macular degeneration [2, 3].

In this system, we are generating the types of image which describe the low vision or central and peripheral vision problems. The images well define the problems related to the above two factors. The patient has to provide the constant support to find out the problem exist in his eye belongs to central vision loss or peripheral vision loss.

2.3 Perceived Image Processing

In proposed system the image database is considered to have the images which is to be shown to the patient and depending upon the patient description the image is again redrawn the screen that image is called perceived image and will be stored in the patient image field of the patient database. Now the processing is done on the perceived image in the rule database to find out the disease. After all the processing disease information will be displayed on the screen for that patient.

3. EXPERIMENTAL RESULTS AND DISCUSSION

The above discussed system is implemented in Matlab R2010a and database of image and rule is created in MS-Access. Number of diseases are considered and based the question answered by the patient, different processing are implemented on the image to find out the problems that patient eye is having. As this a system which is having lot of constraint so we have made number of assumption and patient support to successfully implement our system.
The developed system is evaluated on a PC with a Pentium IV 1.0 GHz core and 1GB RAM. The input image is displayed on the screen and the image size is 320*240 pixels size. After processed by the proposed system, the output image is projected to the Display screen. The experimental results are shown in the Fig. 3.

Fig. 3: (a) Original Image (b-f) Visual Defected Images Generated by the System
Rule database consists of if-then else conditions, symptoms are defined in it and based on the perceived image processing the diseases, precaution, symptoms will be displayed on the output screen.

As we know that this type is system is successfully only when the decision will be taken by the expert. In this results are perfectly displayed but require human expertise for final decision.

4. CONCLUSION
A prototype of the system has been created and implemented successfully. Three types of vision defect, including colorblind, low vision and visual field deficiency are examined by the system. The results shown by the system are quite efficient and a person can find out the defects his/her eye is having. Though the final decision cannot be generated by the person. Human expertise that is doctor is required to give the final decision. Though this type of system is quite useful in early detection of some of the problem the patient eye is having. We are working further on the system to make it intelligent to enhance its decision making. So that human expertise can be minimized.

REFERENCES