Target Recognition Task Based Online System for Refractive Error Measurement Using Font Transformations

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Abstract: - Problems in visual acuity are quite common in different age groups all over world. Early detection of refractive error can save patients from future complications. Patients suffering from problems in visual acuity due to age, environment and inherited diseases need an onsite inspection by a specialist. We have developed a handy online system for the diagnosis and possible spectacle solution based upon a cost effective and efficient technique using font magnifications and minifications. Our system eliminates the need of physical eyesight checkup and can be used very conveniently at home. The beauty of our system is that it does not require any extra hardware or skills. Experiments were conducted using this system on a wide range of patients and we found very promising results.

Key-Words: - Font transformations, Myopia, Hyperopia, Visual acuity, Refractive error, Eyesight testing

1 Introduction

An onsite inspection by an eye specialist is needed by the patients suffering from different kind of vision related diseases. These vision related diseases may be due to eye lens or due to some partial or complete disfunctioning of optical nerve. Different forms of vision problems are but not limited to myopia, hyperopia, astigmatism, keratoconus and monocular diplopia. The main focus of our research is on the measure of refractive error for myopic patients by using a computer based image processing technique. Our approach eliminates the need of physical examination by a specialist. We have developed an online computerized system to investigate myopia using font transformations (magnification and minification). We have employed an efficient and effective technique to diagnose the refractive error of a patient. Refractive error is the cause of quarter of blindness and half of low vision [1]. There are different types and number of eye diseased patients depending on different age groups [2]. A comprehensive population survey based on relationship of visual acuity problems with age, gender, diabetes and smoking is presented in [3]. There are different studies on the effect of font size [4] and computers on readability, eye health and vision. In the following section we will discuss myopia in detail, which is the main focus of our research.

2 Myopia

Our research is focused on providing a spectacle solution for myopic patients. Low visual acuity due to myopia and hyperopia can be controlled by suitable spectacles. Other eye diseases such as astigmatism, keratoconus and monocular

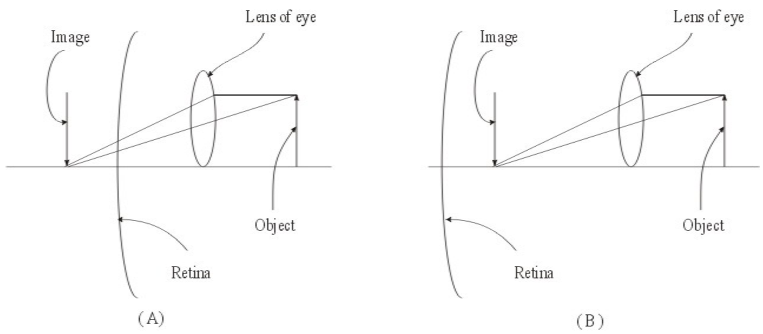

Fig. 1. Eye diseases (A) Hyperopia (B) Myopia

diplopia need medication and or surgery. In hyperopia or farsightedness the image of an object is created at the rear of the retina, as shown in the Fig.1 (A), which causes the image to be indistinct. Myopia or nearsightedness is an eye disease that emerges when an image of an object is formed before retina, as shown in Fig. 1 (B). The people suffering from this disease can not see far objects clearly. This disease, if unattended can lead to other visual disorders like low vision and blindness. In children it can affect their erudition and learning pace. It also causes faulty decisions for visualization based decisions.

3 Our Approach - Font Transformations

The main emphasis of our approach is to facilitate a possible patient with low visual acuity at his or her own desk with the use of a computer. Our approach does not need any extra hardware as in the case of Crossman et al. [5]. The flow of our approach is: (1) Development of Modified Snellen's Chart (MSC), (2) Experimentation on different patients using different image processing techniques like blurring, sharpening and font transformations and (3) Tabulation and analysis of results.

3.1 Modified Snellen's Chart (MSC)

Our MSC shown in Fig. 2 has some differences from the standard Snellen's chart. We have used Arial font instead of optotypes. The conventional nine characters of a standard Snellen's chart are also replaced by the characters shown in Fig. 2. This MSC was developed through an extensive experimentation on persons of different ages from readability point of view. Another reason for choosing Arial font was that it does not produce optical illusions due to its squarish nature.

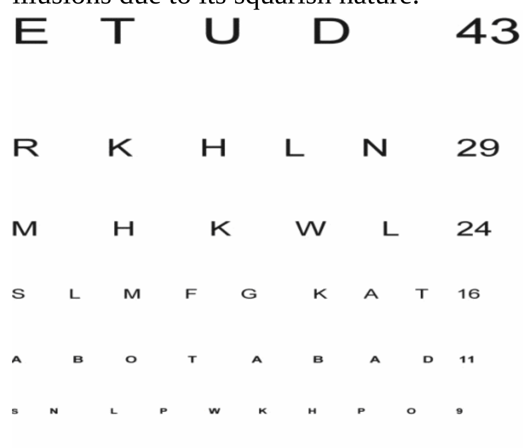

Fig. 2. Modified Snellen's chart (Not in actual size)

3.2 Experimental Setup

We adopted different image processing techniques like sharpening and blurring [6, 7, 8] to measure refractive error of a person. An extensive experimentation was performed on a number of people of different age groups however these approaches did not show appropriate results. Sample test images using blurring and sharpening are shown in Fig. 3.

Based upon thses images, different people were tested for their visual acuity. Approximately a dataset of about 500 people

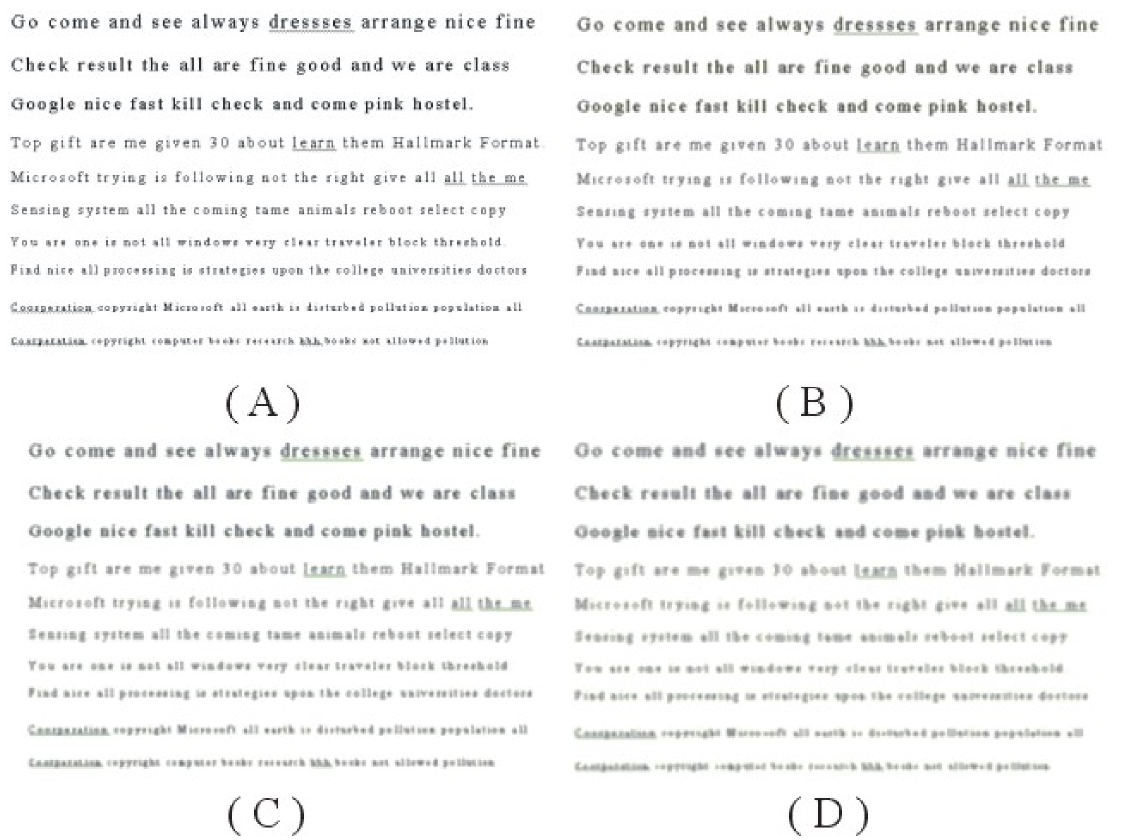

Fig. 3. Sample test (Not in actual size) (A) Original image (B) Blur 3x3 (C) Blur 4x4 (D) Blur 5x5

Table 1. Results after conducting the blur tests

Refractive Error	Original Image	Blur 3x3	Blur 4x4	Blur 5x5
-0.25	All Clear	Blur	More blur	More blur
-0.50	All Clear	Blur	More blur	More blur
-0.75	All Clear	Blur	More blur	More blur
-1.00	All Clear	Blur	More blur	More blur
-1.25	None clear	1st line much clear	Much clear till 2nd line	None clear
-1.5	Much clear till 4th line	No improvement	No improvement	No improvement
-1.75	Last two lines not clear	No improvement	No improvement	No improvement
-2.00	Line 1 not very clear	First 3 lines clear	No improvement	No improvement
-2.25	None clear	A little clear but not readable	No improvement	No improvement
-2.50	None clear	None clear	None clear	None clear
-2.75	None clear	None clear	None clear	None clear
-3.00	1st line little clear	1st line clear	No improvement	No improvement

Table 2. Relation between font size and refractive error with corresponding calculating function

Font Size	Refractive Error		Function
	Estimated	Actual	
6	-0.25	-0.25	$0+\frac{FontSize-4}{8}$
8	-0.50	-0.50	
10	-0.75	-0.75	
12	-1.00	-1.00	
14	-1.25	-1.25	
16	-1.50	-1.50	
18	-1.75	-1.75	
20	-2.00	-2.00	
24	-2.25	-2.25	$2+\frac{FontSize-20}{16}$
28	-2.50	-2.50	
32	-2.75	-2.75	
36	-3.00	-3.00	
40	-3.25	-3.25	
44	-3.50	-3.50	
48	-3.75	-3.75	
52	-4.00	-4.00	
76	-5.00	-5.00	$4+\frac{FontSize-52}{24}$
100	-6.00	-6.00	

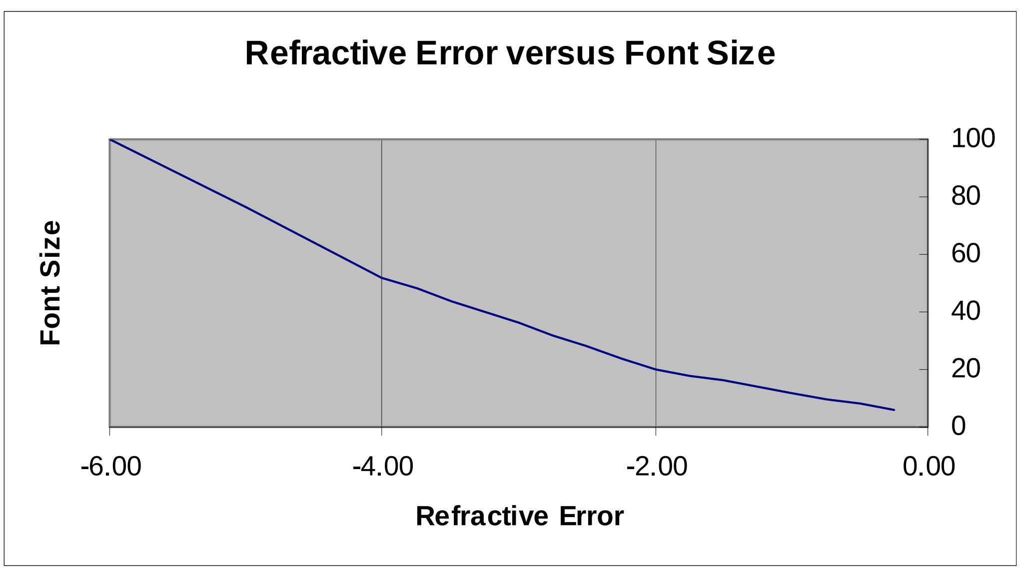

Fig. 4. Piecewise linear trend of refractive error versus font size

$$\mathrm{Re}\,fractiveError = -\begin{cases} 0 + \dfrac{FontSize - 4}{8} & | \quad 4 \le FontSize \le 20 \\ & \wedge \quad FontSize = FontSize + 2 \\ 2 + \dfrac{FontSize - 20}{16} & | \quad 20 \le FontSize \le 52 \\ & \wedge \quad FontSize = FontSize + 4 \\ 4 + \dfrac{FontSize - 52}{24} & | \quad 52 \le FontSize \le 100 \\ & \wedge \quad FontSize = FontSize + 6 \end{cases} \tag{1}$$

$$\mathrm{Re}\,fractiveError = -\left[2n + \frac{FontSize - 4 + 8n(n+1)}{8(n+1)}\right] \tag{2}$$
$$| \quad 4 + 8n(n+1) \le FontSize \le 4 + 8(n+1)(n+2)$$
$$\wedge \quad FontSize = FontSize + 2(n+1) \quad \wedge \quad n = 0,1,2,.........$$

was taken. The experiments showed that these images do not produce consistent results as shown in Table 1. Some people could read the lines which were not readable by other people with same age and visual acuity.

The next approach was to use font transformations, mainly font magnifications and minifications. The experiments were performed in a closed environment. The monitor to eye distance was fixed at 1 meter. Another constraint is that the eyes and the monitor should be in parallel. The experiments showed very promising results. Sample results are summarized in Table 2.

3.3 Conclusion

Based upon actual date after our experiments, we see that different font sizes correspond to associated refractive error of a patient. Our analysis showed that the measure of refractive error is not a linear function of font size. This analysis is depicted in Fig. 4. It can be seen that the trend between refractive error and font size is a piecewise linear function. Equation 1 is the mathematical modeling of our results. Equation 1 can be summarized as in equation 2.

We measured the font size at which a person has optimal visual acuity and then the refractive error is calculated using equation 2.

The experiments showed that our online computerized eyesight testing system is reliable for proposing spectacle number for myopic patients.

4 Summary

We have developed a computerized system to measure the refractive error of a person based upon font transformations. The main theme in our approach is the use of font magnifications and minifications. We analyzed the results and determined that the trend between refractive error and font size is a piecewise linear function and the mathematical modeling is depicted in equations 1 and 2. We tested our system on different patients and found very accurate results.

5 Future Work

Our research can be extended to hyperopia. The main problem with such computerized solution may be the illumination produced by the monitor. In order to test patients for hyperopia, the monitor to patient distance can not be as far as 1 meter as is the case for myopic patients in our approach. The distance should be in between one to one and a half inches to test the near sightedness or hyperopia. This limitation may introduce some limitations which should be catered before designing the experimental setup. A possible solution may be the use of low radiation screens such as LCD instead of CRT monitors. Interested readers may refer to [9, 10].

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