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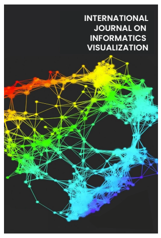

Study the Field of View Influence on the Monchromatic and Polychromatic Image Quality of a Human Eye

Adeeb Mansoor Qasim [a], Mohammad Aljanabi [b,*], Shahreen Kasim [c], Mohd Arfian Ismail [d], Taufik Gusman [e]

[a] *Computer Science Department, AL-Salam University College, Hay AL-khadra'a, Baghdad, 10022, Iraq*
[b] *Computer Science Department, AL -Iraqia University, Baghdad, 10054, Iraq*
[c] *Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia (UTHM), Address, Johor, 86400, Malaysia*
[d] *Faculty of Computing, College of Computing and Applied Sciences, Universiti Malaysia Pahang, Malaysia*
[e] *Department of Information Technology, Politeknik Negeri Padang, Sumatera Barat, Indonesia*
*Corresponding author: *mohammad.cs88@gmail.com*

***Abstract*— In this paper, the effect of the eye field of view (known as F.O.V.) on the performance and quality of the image of the human eye is studied, analyzed, and presented in detail. The image quality of the retinal is numerically analyzed using the eye model of Liou and Brennan with this polymer contact lens. The images in digital form were collected from various sources such as photos, text structure, manuscripts, and graphics. These images were obtained from scanned documents or a scene. The color fringing, chromatic aberration addition to polychromatic effect was studied and analyzed. The Point Spreads Function (known as PSF) and The Modulation Transfers Function (known as MTF) were measured as the most appropriate measure of image quality. The calculations of the image quality were made by using Zemax software. Then, the calculation results demonstrate the value of correcting the chromatic aberration. The results presented in this paper showed that the image's form is so precise to the eye (F.O.V.). The image quality is degraded as (F.O.V.) increases due to the increment in spherical aberration and distortion aberration, respectively. In conclusion, the Zemax software used in this study assists the researcher's potential to design the human eye and correct the aberration by using external optics.**

***Keywords*— Eye models; point spread function; modulation transfer function; an aberration.**

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I. INTRODUCTION

An eye is a sophisticated optical device that acts as an optical refractive system consisting of an anterior chamber (where the aqueous humor flows through), cornea, iris, rear chamber, convex crystal lens, retinas, etc. the vitreous body. This construction is heading to create a superior form retinal image. Several models estimated the optical design of the human eye [1] and evaluated and analyzed the optical showing for the eye [2], [3]. The Liou and Brennan eye model is the closest schematic eye for the biological eye. They suggested a gradient refractive index and a rounded optical surface [4], [5].

Refractive surgery, Cataract Surgery (implementation of intraocular lens (IOL)), and the use of corneous lenses as well as medical contact lenses (CL) [6], [7] were useful for vision correction [8]. Awareness flowing interface offers the flow of information to reveal the analysis and processing of data with accurate rules for the association, which assess the layout [9].

Studying the material types used in the manufacture of optical elements mentioned is necessary to get a typical lens to correct refractive errors completely. To evaluate the form of the retinal images of the eye with PSU contact lens, we used idealistic lens purpose software (Zemax-EE) to approach it with the retinal image condition of a healthy eye. Numerical data of Liou and Brennan type [4] and parameters of investigating the crystal lens with aspherical surfaces and the gradient refractive index are shown in Table 1.

TABLE I
AN EYE MODEL- LENS DATUM EDITOR

	Surf: Class	Remark	Radius	
Symbol	Ordinary	OBJEC T	Infinite	
1	Ordinary	INCOME BEAM	Infinite	
2*	Extended Pol..	CL-1FRONT	7.754040	V
3*1	Ordinary	CL-1BACK	7.800000	
4	Coordinate B..			

5*	Ordinary	CORNEA1	7.7700001
6*#	Ordinary	AQUEOUS1	6.4000001
STO#*	Ordinary	PUPIL*	Infinite
8*#	Gradient 13	LENS-FRONT*	12.4000001
9*#	Gradient 13	LENS-BACK*	Infinite
10*#	Ordinary	VITREOUS*	-8.099986
IMA	Ordinary	RETINA	-12.000000

Thick (in dimension)	Glazier	half-Diameter		Conic	
1000.000000		92.146978		0.0000000	
50.00000		0.000000	U	0.0000000	
0.100000	1.63,23.5	4.000000	U	-0.106867	V
7.800000	WATER	4.000000	U	0.000000	
-7.800000	-	0.000000			
0.550000	1.38,50.20	5.0000000	U	-0.1800000	
3.160000	1.34,50.20	5.0000000	U	-0.6000000	
0.000000	1.34,50.20	1.2500000	U	0.0000000	
1.590000		5.0000000	U	0.0000000	
2.430000		5.0000000	U	0.0000000	
16.238830	1.34,50.20	5.0000000	U	0.9600000	
--		5.0000000	U	0.0000000	

At the beginning of optical characteristics, such as contact lenses made out of glass, biomaterials were utilized for CLs manufacturing [10], [11]. The transparency, flexibility, water permeability, and gas are the main factors that characterize the Optical polymers used in the manufacture of visual components for vision correction [12].

II. Materials and Method

This paper studies the effect of the different human fields of view on the behavior of the retina of the people's eye. A comparison was made between these results and the results obtained from Liou and Brennan model lenses). Digital images, such as photos, text structure, manuscripts, and graphics, are electronic photographs taken from scanned documents or scenes [13]. The response of an image for any optical system can be defined by Point Function (MTF). Optical Transfer Function (OTF) is also represented as a function that helps in image performance specification.

PSF and MTF are inconvenient if the object irradiance is continuous, but OTF is the correct choice for this type of irradiance distribution [15]–[17]. Each of PSF and OTF can be calculated mathematically by applying the Fourier transform function of the other. A collecting of wave-front aberrations defines the optical performance of any person's eye and any optical combination (see table (2)) named wave-front error at the pupil's exit [18]. The Zernike polynomial for rectangular, square, and circular aperture can represent These aberration coefficients [19]–[21].

TABLE II
WAVE-FRONT ABERRATION COEFFICIENTS

Wave-front aberration	Spherical aberration	Coma	Astigmatism	Field curvature Petzval
Symbol	$w040$	$w131$	$w222$	$w220P$

Distort-ion	Axial color de-focus	Lateral color tilt	Field curvature sagittal	Field curvature medial	Field curvature tangential
$w311$	$w020$	$w111$	$w220S$	$w220M$	$w220T$

Seidel polynomials in polar coordinates can be described mathematically as follows:

$$w = \sum_{ijk} w_{ijk} H^{i} \rho^{j} cos^{k}\phi \qquad (1)$$

(w_{ijk}) is the wave-front aberration coefficient has positive or negative values. It has dimensions of length (usually in the units of the operating wavelength). The maximum value of the coefficient indicates the achieved term. i, j, and k are the fractional image height (H) powers, The fractional pupil radius (ρ), and ϕ in the cosine term, respectively. Factors in each term of the polynomial and (*ijk*) subscript indicate a specific aberration coefficient in the Siedel polynomial. The factors *H* and ϕ have value ranges between 0 and 1, while the cosine has values between -1 and 1.

The use of the normalization function of pupil and field coordinates. The five lower order terms in the series are Seidel coefficients, where the sum i + j = 4. These are the most common aberrations: the first three aberrations are spherical, coma, and astigmatism, which affect the PSF quality, while the other two aberrations are field curvature and distortion that affect the PSF lateral and longitudinal off-axis field points positions.

PSF can be computed by the wave-front aberration [18], [22]. The pupil function f (u,v) in general is defined as follows:

$$\mathrm{f}\,(\mathrm{u},\mathrm{v}) = \tau(x,y) exp^{\frac{i\,2\pi}{\lambda} w(x,y)} \qquad (2)$$

Where u and v refer to the pupil's heart and are normalized by the radius of the pupil. τ is the function (of pupil); it explains how the light transmits over the pupil. Within the pupil area, it can be described as 1 and elsewhere as 0. Then the incoherent light PSF is calculated by the pupil function Fourier to transform modulus squares:

$$PSF\ (x,y) = \parallel F[u,v] \parallel^{2} \qquad (3)$$

The mathematical relationship within the function of the complex pupil, PSF and the OTF is shown in figure 1.

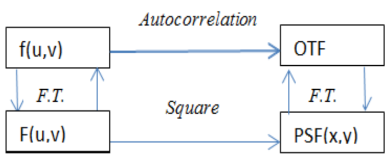

Fig. 1 Mathematical relationship within the function of pupil f(u,v), the OTF, and the PSF [21]

So

$$\mathrm{OTF(v)} = \frac{\pi^{2}}{2\lambda^{2}F^{2}} \int_{0}^{\infty} PSF(x) J_{o}(2\pi v x) x dx \qquad (4)$$

And,

$$\mathrm{PSF(x)} = \frac{2\lambda^{2}F^{2}}{\pi^{2}} \int_{0}^{\infty} OTF\ (v) J_{o}\ (2\pi v x) v dv \qquad (5)$$

where J_o (...) is the first-order Bessel function.

III. Results and Discussion

This paper includes the results of the effect of the human field of view on the retina's human eye performance. These results have been compared with that; the results obtained from Liou and Brennan model (standard human eye) [4]. The (MTF) were calculated for chromatic light (555) nm, Ploychrematic light (470,510,550,610,650) nm with weighing (0.091, 0.503, 0.503 and 0.107) respectively.

A. Monochromatic and Polychromatic MTF for L&B model for Different F.O.V.

Fig. 2 represents the MTF when the source is monochromatic light (555 nm) for different eye F.O.V. (0-60 degrees). This figure indicates that as the F.O.V. increased, the MTF was destroyed, so the vision became worse. This behavior belongs to the increase in distortion aberration as F.O.V. increased. While Fig. 3 shows the MTF for polychromatic light, it has the same behavior as F.O.V.

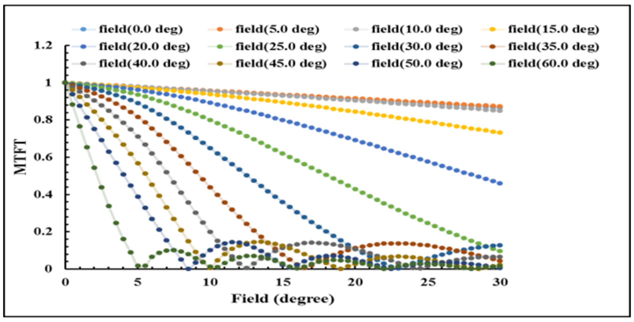

Fig. 2 Monochromatic MTF for L&B model for different F.O.V.

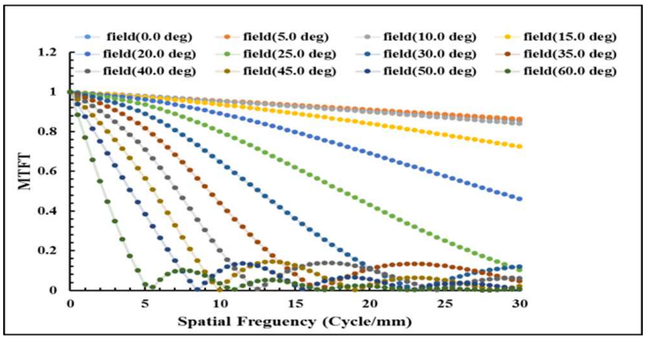

Fig. 3 Polychromatic MTF for L&B model for different F.O.V.

B. Aberration Vis F.O.V. for Eye in Polychromatic and Monochromatic Light

MTF is more affected by F.O.V. This belongs to the contribution of chromatic aberration and monochromatic aberration, as shown in Fig. 4.

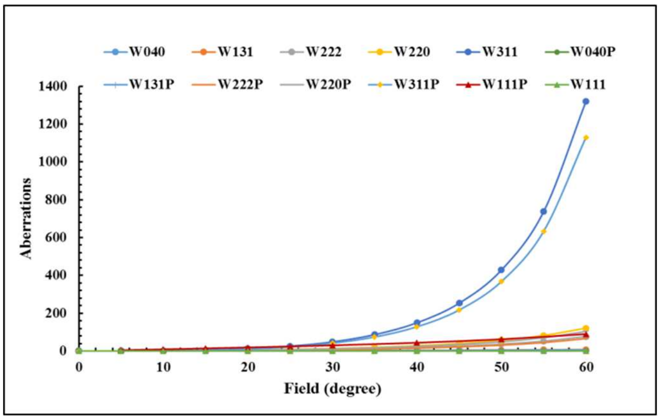

Fig. 4 Aberration Vis F.O.V. for eye in polychromatic and monochromatic light.

IV. CONCLUSION

The eye model of Liou and Brennan [4] is the more accurate model for describing the human eye structure. Zemax software allows the researchers to design the human eye and correct the aberration by using external optics. The more the field of vision gets, the decline in the image, especially when the field is greater than 50 degrees. Alternatively, the future works, it is hoped that the present study can be implemented in the field of simulation software for schematic eye models and then assist the researcher for further study in this domain, such as in these works [23]–[32].

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