Computer Analysis Of A simplified Eye Model

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Abstract

Computer analysis of simple eye model is performed in the present work by using the Zemax optical design software 2000E . The most important optical parameters of the eye were calculated such as the effective focal length (EFL) , the image spot size at the retina and found to be in a reasonable agreement with the values needed for the laser retinal treatment .The present eye model leads to an effective wavelength and we found the image spot diagram at the surface of the retina and the wavefront error which are provided at zero field angle. This gives a good evidence of the validity of the model in one hand, and can be used to determine the compatibility of any optical design intended for visual applications. By using the pulse frequency doubled Nd:YAG laser 532 nm can be used for the to treatment the retina.

Introduction

In an optical point of view, the human eye is considered as a complex imaging system. Utilizing computer analysis of a simplified eye model, allows us to better understand the basics of the eye functions and the limits of visual resolution (1). Recently, much interest was devoted to design and analysis by using Zemax software 2000E of a diffraction limited cat's eye retroreflector (2,3) because of its applications in spatial light modulators.

The recent researches were concentrated in the field of scanning laser opthalmoscopy to measure and correct the high order aberrations of the human eye and to calculate the optimal pupil size in the human eye for axial resolution (4,5).

Most imaging systems are well described by a sequential list of surfaces, each of which defines the boundary between one media and the next. They are traced from the object surface to each surface in a specific sequential order. The Zemax optical design program is a comprehensive software tool for optical design and is used in the present work for the computer analysis of the simple eye model.

Materials and Methods

The eye model

The eye, as an optical device , may be thought as a system of optical components, of about one inch in diameter, filled water like fluid. The transparent surface through which light enters the eye is called the cornea. The convex outer surface of the cornea provides the majority of optical power to be transmitted through the eye. At a few millimeters behind the cornea, there is a relatively thick double convex lens, the eye lens. Just in front of the eye lens, there is an opaque disk with an opening at its center which is referred to as the iris. The eye lens focuses the light entering the eye at the back of the eye, the retina. The retina is the most important portion of the eye that resolves the detail of the image or the visual resolution.

By using the Zemax optical design software 2000E, the most important optical parameters of the eye were calculated such as the effective focal length (EFL) and the image spot size at the retina.

Results and Discussion

Fig. (1) shows the model of the eye developed in this work by using the optical design Zemax software 2000E.The radius of curvature, thickness, diameter and glass information is provided in Table (1). All surfaces are spherical.

The light originates from the second harmonic generation of the Nd:YAG laser emitting at the wavelength of 532 nm. It was mentioned in (1) that the standard point of maximum accommodation is at an object distance of 254 mm. This distance is often referred to as the close point of a typical eye. In the present model and for the purpose of making the lens nearly equiconvex, the value of 10 mm is taken into consideration. The present eye model leads to the effective wavelength (EFL)of 16.3406 mm. This value is in an excellent agreement with the corresponding value of 16.7 mm obtained in ref. (1) at the object distance of 6.2 mm. The slight difference is due to the difference in the object distance between the case presented in the present work and the value used for the purpose of the model presented in (1). Furthermore, the image space numerical aperture NA is found to be 0.2756169, while the object space NA is 0.7071068 .

The image spot at the retinal surface is shown in Fig. (2). The central diameter of the image is found 184 μm, while the blur circle outside this central image spot is due to aberration.

This value of the central spot diameter can be considered reasonable for the case of the frequency doubled Nd:YAG laser at the eye retina, since it is within the range of the laser spot size needed by the surgeons for the laser retinal treatment.

Plots of wavefront error are provided at zero field angle, in Fig. (3).The aperture coordinates are relative and the scale of the optical path difference runs from 100 to 100 waves. The similarity of the incident and existing wavefront is the most important single figure of merit for the validity of the present model.

Conclusions

1- The present eye model is suitable for computer analysis by using modern optical design software.

2- The present data for the eye model can be used as a reference which can be used to determine the compatibility of any optical design intended for visual applications.

3- The effective focal length (EFL) of the eye system provided in the present work can be considered as one of the important Figure of merit for testing the validity of the present model.

4- The spot size provided by the present work is in areasonable agreement with the value needed for the laser retinal treatment. This gives further evidence of the validity of the model

References

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Table (1) : The surface data for the Zemax software 2000 E(6)

Surf.	Comment	Radius of curvature, mm	Thickness mm	Glass type	Diameter, mm
OBJ	-	infinity	10	Air	-
STO	-	infinity	-	Air	20
2	CORNEA	7.98	1.15	MgF_2	10.96213
3	AQUEOUS	6.22	2.39	SEAWATER	10.86602
4	LENS	10.2	4.08	CaF_2	10.90885
5	VITREOUS	-6.17	17.15	SEAWATER	10.9355
6	-	infinity	0	-	3.32571
IMA.	-	infinity	-	-	3.32571

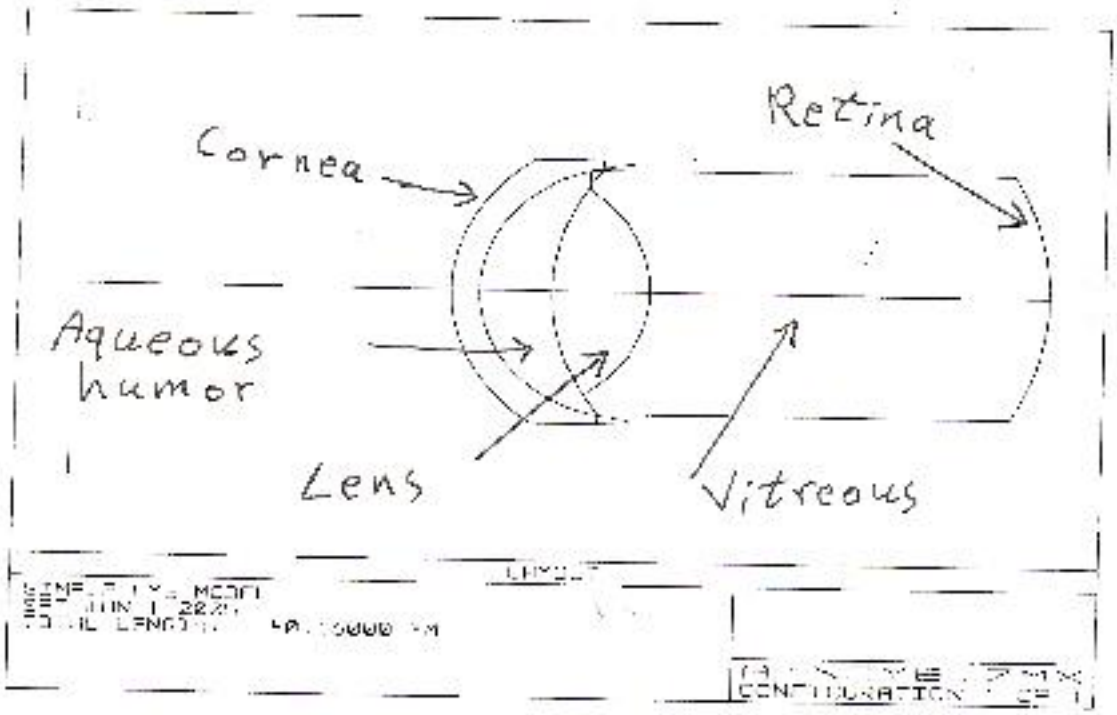

Fig. (1a) 2D Layout of the simplified eye model

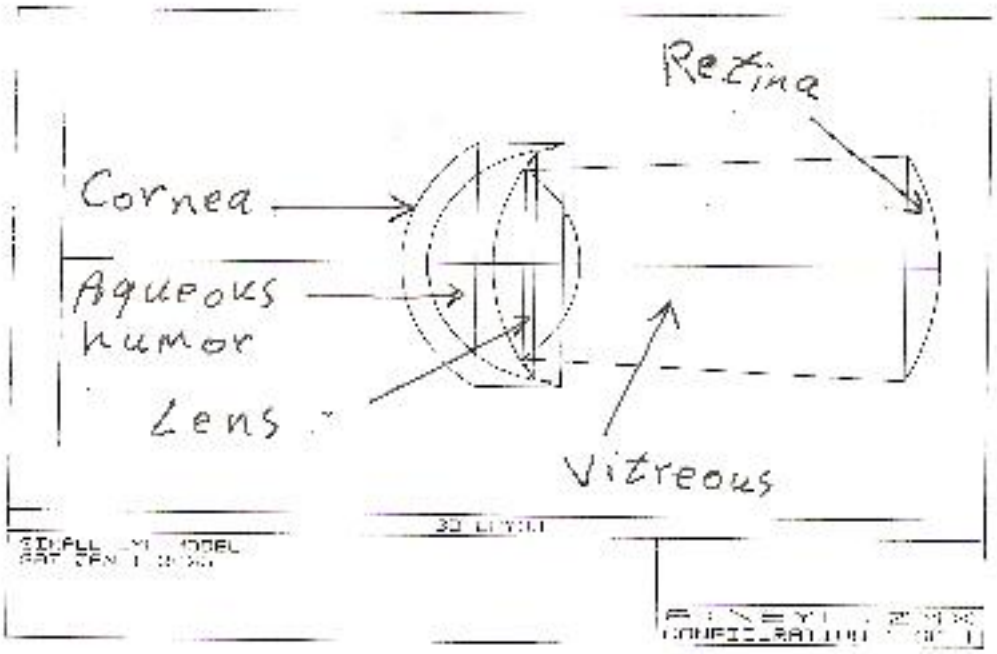

Fig. (1b) 3D Layout of the simplified eye model.

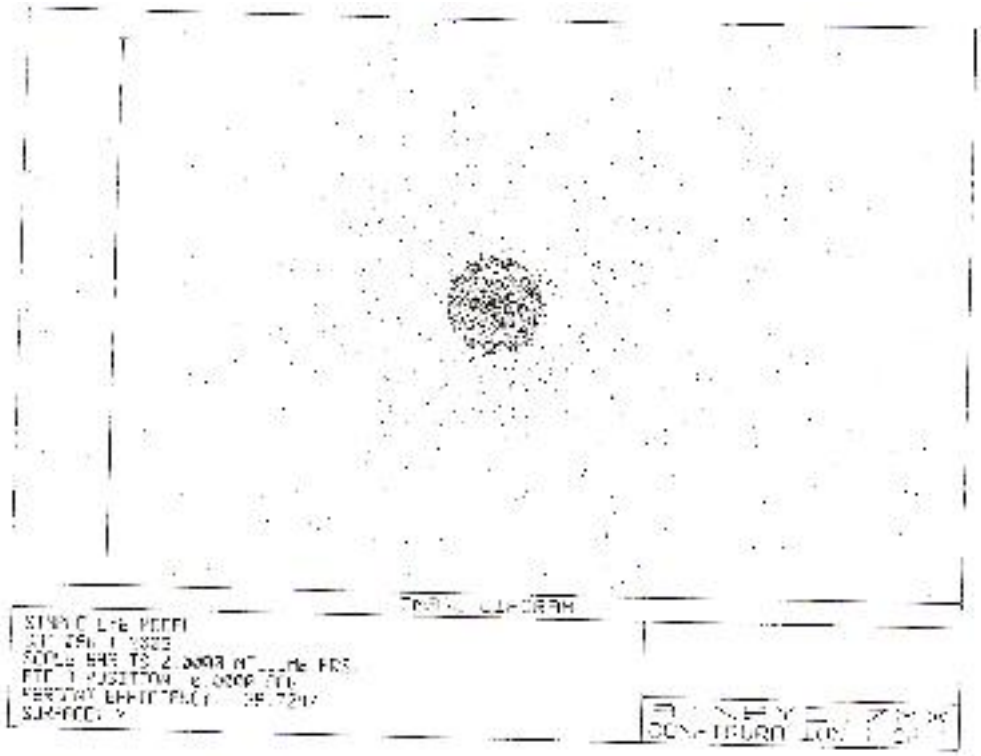

Fig. (2a) Image spot diagram at the surface of the retina

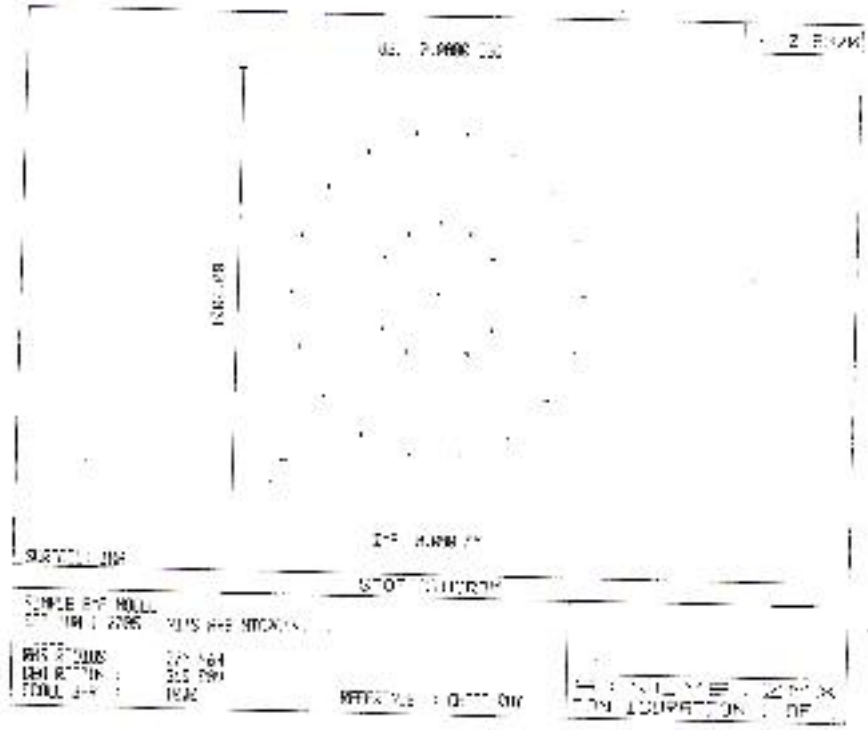

Fig. (2b) spot diagram of the simplified eye model .

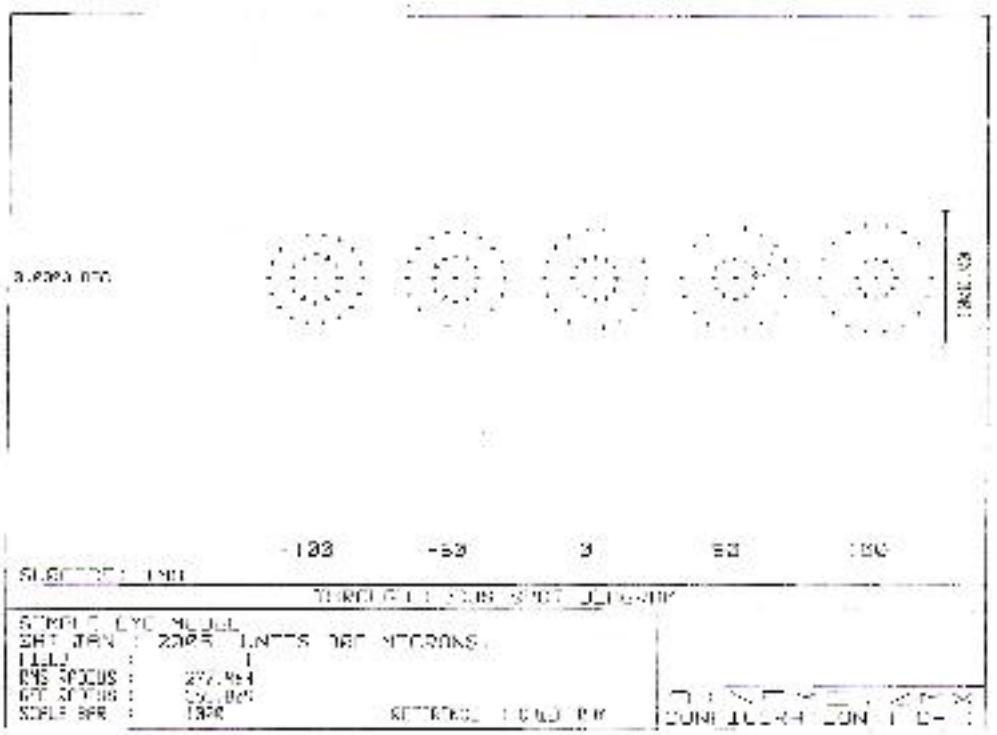

Fig. (2c) focus spot diagram .

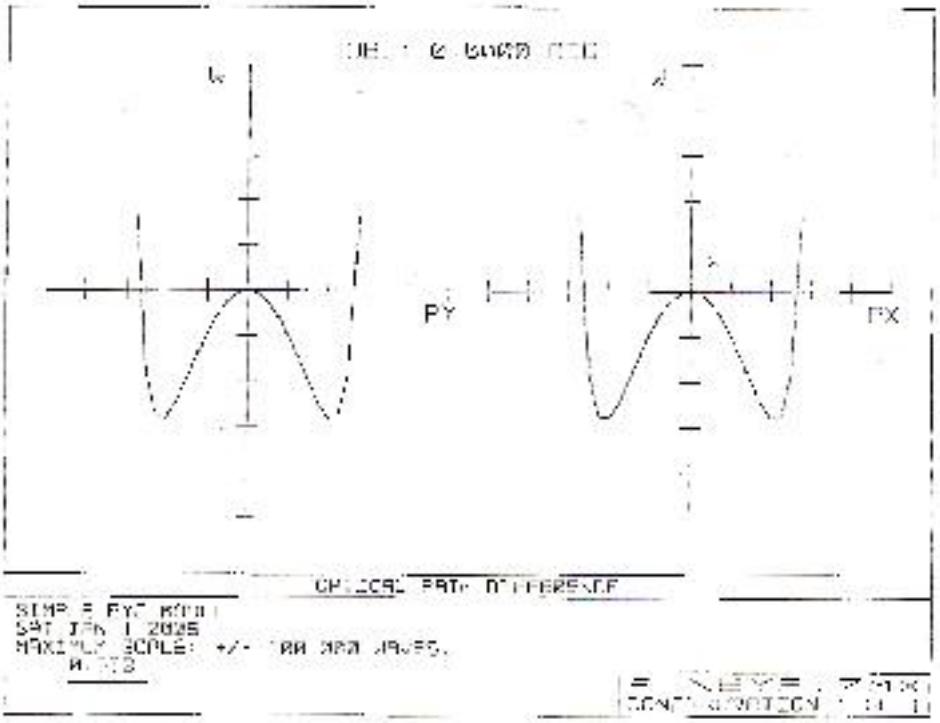

Fig. (3) Wavefront error as a function of operator at zero degree for the optimal .

استخدام الحاسوب لتحليل إنموذج مبسط للعين

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الخلاصة

إن التحليل بأستخدام الحاسوب لانموذج مبسط للعين قد قدم في هذا البحث باستخدام برنامج التصميم البصريZemax software 2000E. و قد حسبت المقايس البصرية المهمة للعين مثل (EFL) الطول الموضعي المؤثر، حجم الصورة في الشبكية. وكذلك وجد توافق معقول مع القيم المحتاجة الى علاج الشبكية بالليزر. الانموذج المستخدم للعين قاد الى معرفة الطول الموجي المؤثر وقد تمكنا من ايجاد صورة بقعة الليزر على الشبكية باستخدام ليزر Nd:YAG النبضي ذي التردد المضاعف 532nm الذي يمكن استعماله لمعالجة الشبكية.

وقد أعطت هذه النتائج دليلا واضحا على امكانية تطبيق هذا الانموذج من جهة ومن جهة أخرى يمكن استخدامه ليحدد تطابق أي تصميم بصري يحتاج الى التطبيقات البصرية.