Design Of Multilayer Physical Model Of Human Eyeball Based on a Physiological Dynamic Parameter Using COMSOL Multiphysics®

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Introduction:-Simulation has significantly contributed in the field of ophthalmology to progress in visual treatments. 3D Simulation model could help the researchers to learn more information. Vision captures, transmits and interprets the visual information[1]. Simulations ensure each 3D model outcome demonstrating the real human eye behaviour. Precise 3D modelling of human eye ball provides a powerful tool for patient specific diagnostic, treatment and to predict visual performance. A multi-physics knowledge based approach is used to parametrically model the human eye structures [3]. Dozens of schematic eye models mimicking the structure of the eye have been proposed since the beginning of the 20th century. There are different standards of eye model illustrated in various research papers, Simplified Gullstrand eye model, Full Gullstrand eye model, Theoretical eye of LeGrand model, Simplified theoretical eye of LeGrand model, The model eye of Walker model, Reduced eye of Emsley model, Generalized reduced eye model, Kooijman eye model, Navarros chromatic wide-angle eye model and Liou–Brennan eye model[1].

•**Materials and method:-**The computational modelling of the eyeball necessitates interplay between experimental results and numerical approximation of simulation. Review shows that only few eye components are modelled rather than taking real behaviours into account. Not all the models are suitable for predicting and analysing the required particular feature. There is need of complete solution which includes the thermal, electrical, mechanics and optical characteristics of the eye. We wanted to model the entire eye and adapt its properties to look at different outcomes. The parametric eyeball model consists of the cornea, lens, sclera, retina, and choroid, aqueous chamber, vitreous chamber. Table 1 give the steps involved in design of eye model. Fig 1 gives the various parts of the human eye.

Table1:-Factors considered for EYE model

Surface area	Type of tissue
Geometric area of each Tissue	Electrical, optical, mechanical properties of each tissue

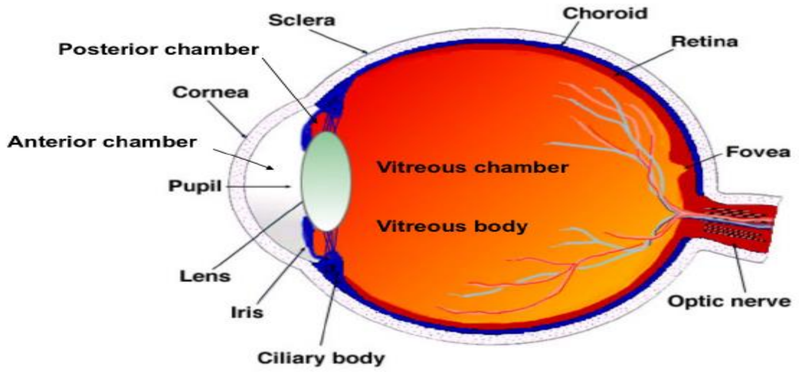

Fig:1 Structure of the eye

Ideally, the cornea forms a sphere it is more curved in the vertical than in the horizontal meridian. The sclera forms the posterior opaque approximately five-sixths of the fibrous tunic of the eye. Its anterior portion is visible, and constitutes the white of the eye [1,5]. The sclera is thickest behind and gradually becomes thinner when traced forwards. The choroid is firmly attached to the margin of the optic nerve, and slightly placed at the points where vessels and nerves enter it. The lens of the eye is a transparent biconvex body of crystalline appearance placed between the iris and the vitreous. Its axial diameter varies markedly with accommodation. Like all lenses, that of the eye presents two surfaces: anterior and posterior, and a border where these surfaces meet, known as the equator. The anterior surface is the segment of a sphere [1,5]. The above said structure of eye and its geometry is shown in fig 2. The final structure and geometry of eye shown in fig. 2 and fig. 3 are designed using CAD and imported in COMSOL Multiphysics® shown in fig 4.

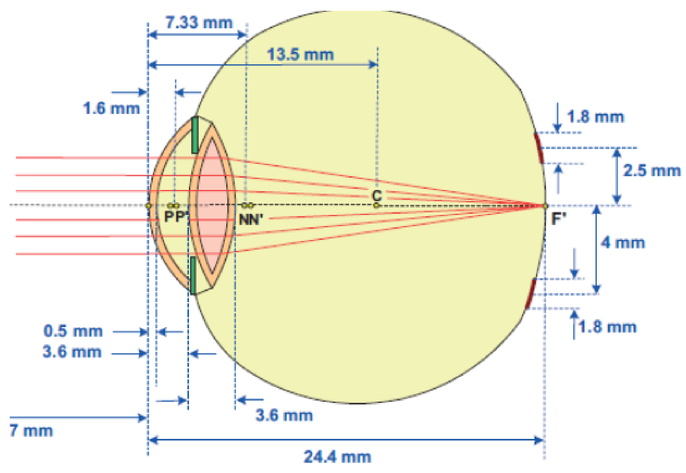

Fig2:Dimensions and lengths of the human eye[1]

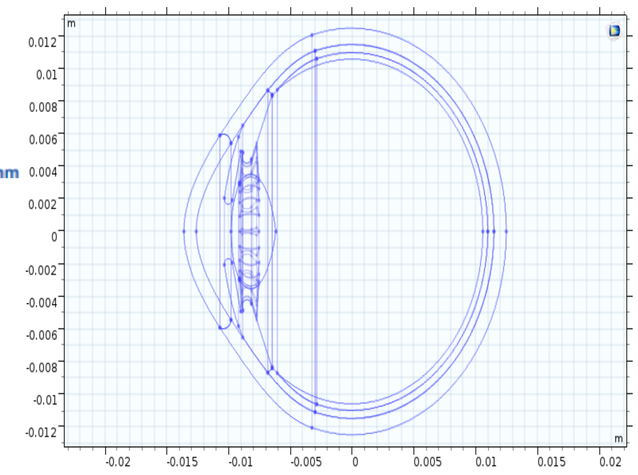

Fig3: Physical representation of COMSOL® 2D model of eye

s.no	Tissue	Cornea	VH	Sclera	Iris	AH	CB	Lens
1	Thermal conductivity K (Wm_1K_1)	0.58	0.603	1.0042	1.004	0.58	1.004	0.4
2	Specific heat C (J kg_1K_1)	4178	4178	3180	3180	3997	3180	3000
3	Density ρ (kgm_1)	1050	1000	1100	1100	996	1100	1050
4	Electrical Conductivity σ (S/m)	0.5	1.55	.56	1.1	1.62	0.037	0.32
5	Refractive indices	1.337	1.336			1.337		1.42

REFERENCES:

1. Herbert Gross, “Handbook Of Optical Systems: Vol. 4 Survey Of Optical Instruments”, WILEY-VCH Verlag Gmbh & Co. Kgaa, Weinheim 2008
2.Teerapot Wessapan A, Phadungsak Rattanadecho, “Specific Absorption Rate And Temperature Increase In The Human Eye Due To Electromagnetic Fields Exposure At Different Frequencies”, International Journal Of Heat And Mass Transfer 64 (2013) 426–435
3.Withanage D. Mahathanthila, “MODELING OF DRUG DELIVERY TO THE HUMAN EYE”, Mechanical Engineering, California State Polytechnic University, Pomona, 2017
4.Chen K, Rowley AP, Weiland JD, Humayun MS. 2014. “Elastic Properties Of Human Posterior Eye”. J Biomed Mater Res Part A 2014:102A:2001–2007.
5.Ju Ying, Yang Hao, Wang Boliang, Xie Jiezhen “Multilayer Physical Model Of Eyeball With Application To Simulation Of IOP Increase, International Symposium On Computer Science And Computational Technology”, 2008: 978-0-7695-3498-5/08 $25.00 © 2008 IEEE