DEVELOPMENT OF A DIGITAL SYSTEM FOR CAPTURE OF IMAGES OF THE FUNDUS EYE FOR ANGIOGRAPHY AND RETINOGRAPHY

Erica G. de Carvalho, Jesulino B. dos Santos, Alexandre L. Bianchi, Francisco Scanavino, Tatiana F. P A Taveira, Fátima M. M. Yasuoka, Jarbas C. de Castro N. ♣
Daniel dos Santos Jr, Leonardo Packer F., Guilherme C. de Castro, Moisés S. da Silva, Edson R. D. Minetto, Mário Stefani ♣♣

♣ IFSC – USP
♣♣ OPTO ELETRÔNICA S.A.

Address
Erica@opto.com.br

Abstract

We have developed an ophthalmological instrument used to accomplish diagnoses and analyzes of the fundus eye. This device is a compact and versatile digital system, which allows capturing, processing and filing the image in real time by the hardware and software dedicated specifically for this purpose.

Introduction

In this work we are developing a digital system for capture images of the funds eye, which purpose is obtaining the evaluation of the retina dynamically and with high resolution. The proposal of this system is automating the traditional system of analysis of the fundus eye, named fundus camera. The traditional fundus camera uses a photography camera to capture the image, while the most modern systems use the image acquisition system in order to substitute the photography camera and its inconvenience techniques of film revelation. In this project we have developed the optical, mechanical and electronic system, in order to make more compact and versatile equipment. The image capture is performed by a digital system in form of photos or films, allowing the manipulation of image and data quickly, easily and in real time.

This kind of ophthalmological instrument permits to perform diagnostics and analyses of anomalies in the retina, through a sequence of images of the patient's fundus eye. The exam of fluorescein angiography is obtained after the application of a substance named fluorescein in the blood vessel. When the fluorescein absorbs the blue light, its molecules become unstable for the energy level elevations of its electrons. When the electrons return to ground state occurs the emission of luminous energy with wavelength between 510 and 580 nm[1],[2]. The functioning of the fundus camera it is based in two filters: the excitator (blue) and the barrier (green). The ideal combination of these filters allows the capture of the fluorescence, creating a sequence of the digital images of the retina in definite intervals and in real time. Besides the exam of fluorescein angiography, it can also be perform the color angiography and the red free exam (It is the image of the retina free of the red band of the radiation specter, using a green filter as excitator filter). These images are captured by a high-resolution camera, whose commands of acquisition and file are executed by the software and hardware dedicated for this specific purpose. This software is being developed to perform the image processing, thus the ophthalmologist can get all the necessary information to accomplish the diagnosis of the angiography exam. A good advantage of this system is the capability to file the data in an efficient database.

Experimental Setup

The applied methodology is divided in three blocks. Optical Design, that is responsible for the optical project of the illuminating system, capturing and acquisition of image. Mechanic Engineering, that is responsible for all the mechanical coupling of the optic and electronic components. Electronic and Computation Engineering, that is responsible for the hardware and software automatization of the system. The development of the Optical Design was done through a technique of ray tracing and formation of images[3] aided by the softwares: Code V and LightTools (ORA/Pasadena/USA). With these resources and calculations it was possible to form a uniformly illuminated ring on the patient cornea. This ring is responsible for illuminating the fundus eye, being the image on the retina formed by rays that pass internally to this ring and that are captured by the

optical system of acquisition of image. This technique can be visualized on figure 1. The development of the mechanical part was done aided by the software Solid Works. And, at last, the electronic and computational is being done for the automation of the fundus camera. The capture unity of the system contains two microprocessors that communicate with a CPU whom controls movement of the filter barrier and excitator, also controls focus of the optical acquisition and he intensity of the illuminating system. A digital camera will capture the image with CMOS technology supplying clear images even with low levels of illumination. This camera works on resolutions up to 1288 for 1031 pixels with 24 bits (about 16 million colors), allowing a high quality image capturing. To facilitate the usage, the acquisition unit possess a control panel with all electronic commands that the operator uses regularly, such as: modes of illumination (on/off/intensity), modes of image (photo/video), focus (handspike of focus movement), turn on/off the equipment, examination mode (fluorescein angiography, red free, color retinography). Acquisition of images can be done in two ways: still photographs or movies. For the management of all these modes special software is developed. It is also processing of captured images, allowing calculation of areas of delimited regions, zoom of these regions, overlapping and comparison of images and image stereoscopy. A database manager for the type of data generated is also being developed.

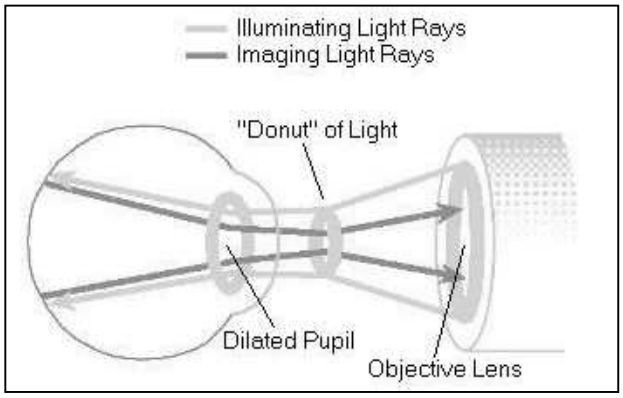

Figure 1: Illumination technique of fundus eye[4].

Results and Discussions

The first achievement was the optical system of illumination, capture and acquisition of the retina's image. It was possible, as mentioned earlier, with the aid of the softwares of optic design: Code V and LightTools (see figure 2).

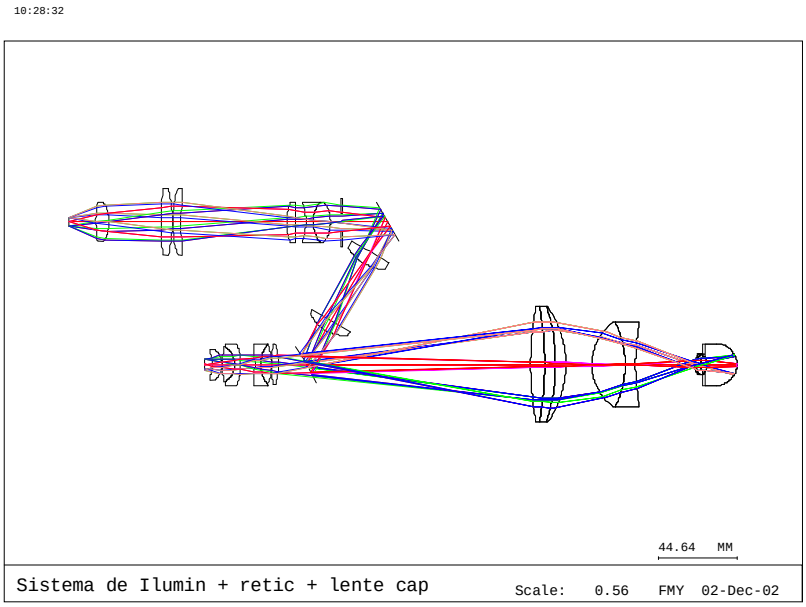

Figure 2: Optical design of digital system (software Code V).

The optical system illustrated in figure 2 was assembled in the mechanics sector following a project done with the software Solid Works of mechanical design (figures 3 and 4). After aligning all the optical components, we obtained our first acquisition of the fundus eye's image. A rabbit was used as a guineapig, since the animal has an eyeball similar to a human one. Later, the method was applied on actual patients. Some of these images are illustrated by figures 5 to 8.

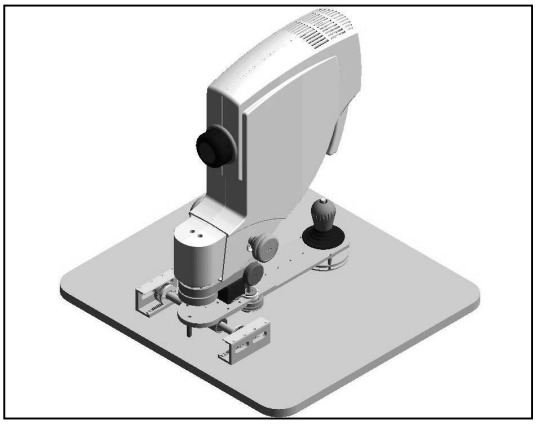

Figure 3: Mechanical design.

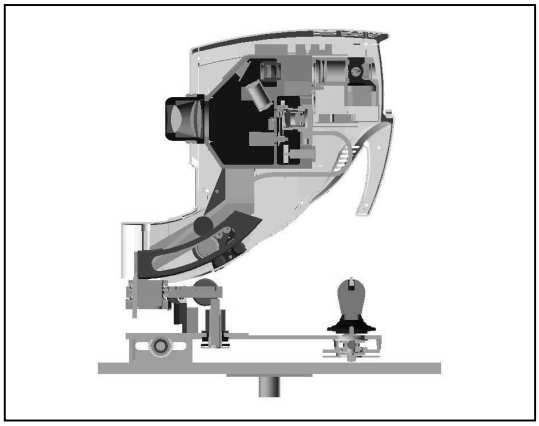

Figure 4: Mechanical scheme of Fundus Camera.

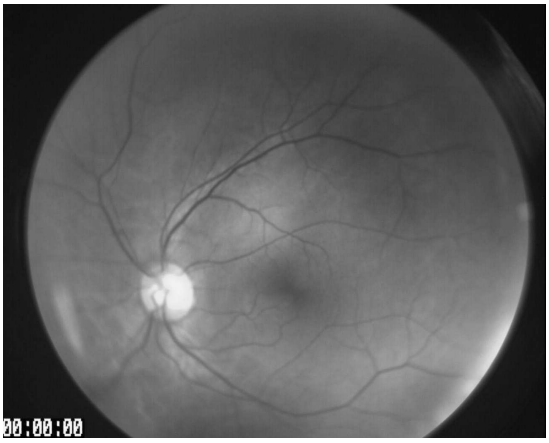

Figure 5: Color angiography (human's eye).

Figure 6: Red free exam (human's eye).

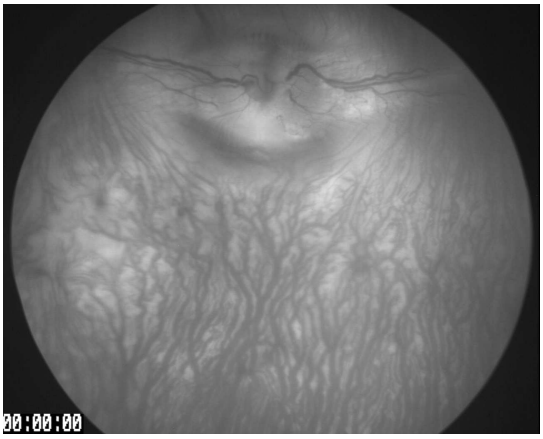

Figure 7: Color angiography (rabbit's eye).

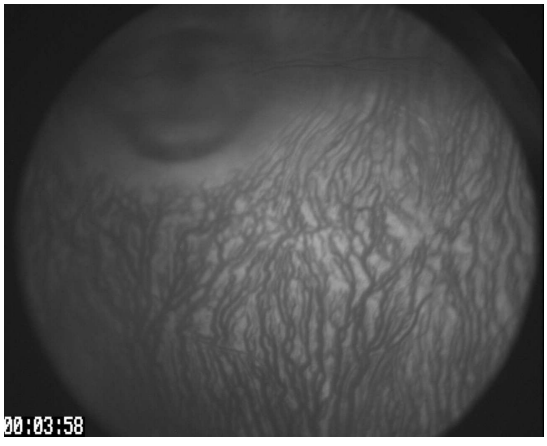

Figure 8: Fluorescein angiography (rabbit's eye).

Conclusions

Many modifications had been made on the optical part until the assembly of the first working archetype. Consequently, the mechanical parts have also gone through changes.

The illuminating system is a very critical one, and some better alternatives are still being sought. Many types of lightbulbs are being tested in search for a more efficient illumination. Another factor we seek to eliminate is the reflection provoked by the own acquisition system. At the present moment, we were able to minimize its effects by way of polarizers, however this method requires more powerful lights. Some alternatives involving optical concepts are being researched.

About the images obtained from the rabbits, they were much better than the ones from human patients. This is easily explained by the fact the rabbit was doped, what prevented involuntary movements during the capturing. In human beings many circumstances such as the involuntary movements of the head due to fatigue and extreme illumination or the blinking of an eye provokes reflection that generates a green tone on the image. Currently some modifications on the light and capture system are being implemented in order to make the system a more stable.

Acknowledgements

PADCT/CNpQ

References

[1] Meyer, R.C.; Vilela, M.; Meyer, G.C.; Angiografia Fluoresceínica; Biblioteca Brasileira de Oftalmologia; Editora Cultura Médica, Rio de Janeiro, 1991.

[2] Tasman, W.; Jaeger, E.A.; Duane's Foundations of Clinical Ophthalmology; vol I, J.B. Lippincott Company, Philadelphia, 1994.

[3] Kingslake, R.; Lens Design Fundamentals, Academic Press, New York, 1978.

[4] Saine, P. J., Fundus Photography - What is a Fundus Camera?; http://www.opsweb.org/Op-Photo/Fundus/CFundus/funphot2.htm, 2002.