A DATA ACQUISITION, PROCESSING AND STORAGE SYSTEM FOR AN OPHTHALMIC STEREOMICROSCOPE

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Abstract. Fotobioftal-1 system is a noninvasive instrument containing an optical stereomicroscope and a data acquisition, processing and storage system. Using EPCO 2000 software, the obtained information leads to optimal treatments for different diseases in the ophthalmologic therapies. In this paper we have followed data acquisition on eye crystalline lens.

Key words: Nd:YAG laser, medical applications, applications in ophthalmology, data acquisition, processing and storage system.

INTRODUCTION

If the aspect of the crystalline lens may be put into evidence by a noninvasive optical device, then the obtained results lead to the possibility for opening the necessary investigations and therapies [1, 3, 4] using a correct technique that can prevent the developing of the diseases (opacity).

One of the medical therapies is based on laser [2]. It is a surgical operation that can also be done in clinics and ambulatory.

Fotobioftal-1 is a noninvasive instrument based on a stereomicroscope combined with a data acquisition, processing and storage system (containing CCD camera and PC computer). The real time images allow knowing the grade of evolution of the disease and regarding of it, the ophthalmologist may get a real conclusion on the therapy which must be used.

MATERIALS AND METHODS

The experimental set-up is a useful combination between a stereomicroscope and an image acquisition photo system.

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The data acquisition, processing and storage system allows to get real time images and these images may be used during a long period of observation of the patients. The device comprises a digital photo camera attached by an adapter to a stereomicroscope in a lateral region, a PC or a notebook with USB interface and also the software. A schematic of the medical process is presented in Fig. 1.

The operating mode of the data system consists in obtaining the images from the visual plane in order to transmit them through the adapter to the digital CCD camera that will transmit the image to PC or note-book through the USB interface.

Special software will process all these images and then these data and images will be stored in a data base. The optical scheme of the Fotobioftal-1 is presented in Fig. 2.

From optical scheme, we can see a splitting optical cube that transmits the image both to the microscope eyepiece and also to the photo camera placed at 90° regarding to the eyepiece's axis. The splitting cube transmits the optical image at 0° and 90° as 50%/50% intensity percent. Its dimension is large enough to include all optical beam.
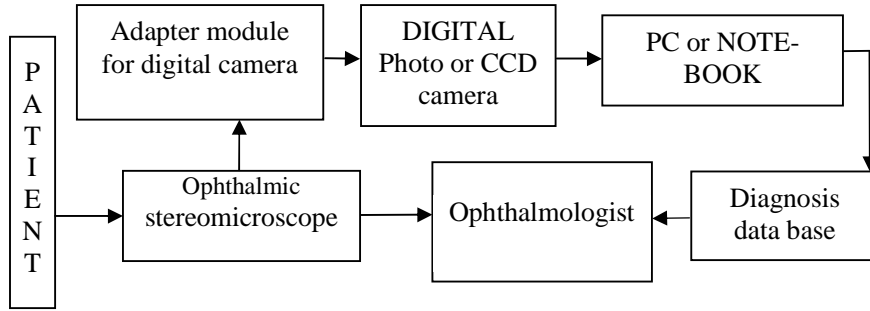

Fig. 1. Optical scheme of the data acquisition, processing and stored system for Fotobioftal-1.

We used for the microscope an objective with a focal length of $f_{ob} = 98.54$ mm, a small telescope placed on a rotating piece in order to obtain the five steps of magnification: 5×, 9×, 16×, 29× and 50×. (Correspondingly, $\gamma_L = 0.316, 0.561, 1.0, 1.784$ and 3.16), a condenser objective with a focal length $f_{aux} = 128.7$ mm and an eyepiece with a focal length $f_{oc} = 20.113$ mm. The digital photocamera has an objective with optical zoom varying the focal length f_F from 7.6 mm to 61 mm.

The adapter system consists of two components:
- beam splitting device
- mechanical tube adapter

The beam splitting device consists of two splitting cubes (corresponding to the two ways of the binocular). They are placed between the binocular and the central part of the stereomicroscope (Fig. 3). Also, a digital photocamera can be attached either to the right or to left side of the device.
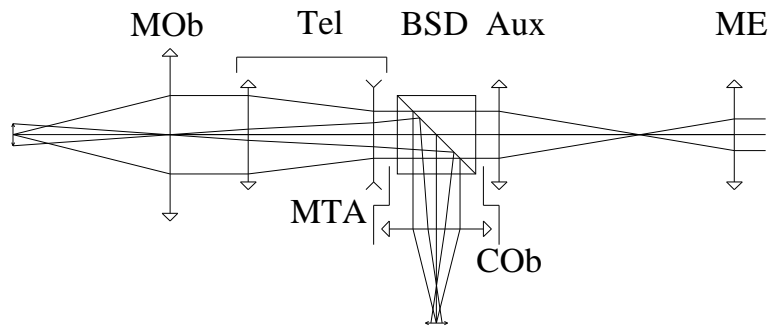
Fig. 2. Optical scheme of the Fotobioftal-1. Mob – microscope objective, Tel – small telescope, BSD – beam splitting device, Aux – condenser objective, ME – microscope eyepiece, MTA – mechanical tube adapter, Cob – digital camera objective.

Stereomicroscope
objective lens

Splitting adapter device
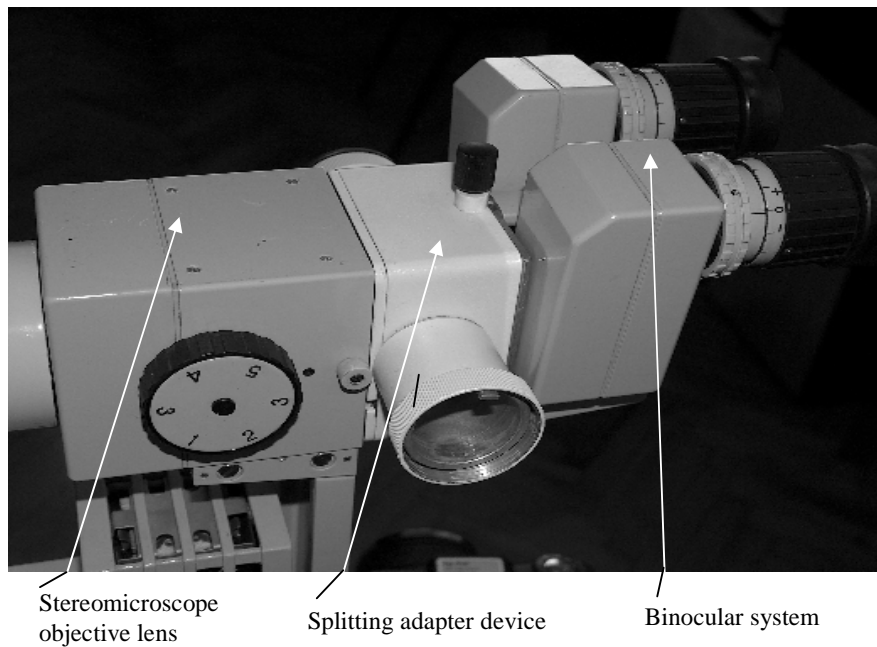
Binocular system

Fig. 3. The splitting device connected to the Fotobioftal-1.

Fig. 3 shows the connecting mode of the splitting device to the Fotobioftal-1. The tube adapter represents the interface between the splitting cubes and the digital photocamera.

The collimated optical beam come out from the stereomicroscope perpendicularly and arrives at digital photocamera objective that is adjusted for infinity (Fig. 4).

Laptop   Data acquisition   Ophthalmic
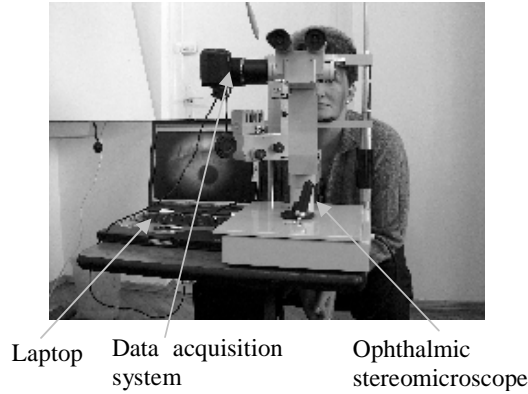   system   stereomicroscope

Fig. 4. Fotobioftal-1.

Fig. 4 shows the Fotobioftal-1 consisting of the stereomicroscope, the splitting device, the digital photocamera, and the computer.

RESULTS AND DISCUSSIONS

Image field η_F of the digital camera is calculated based on the data of its producer. From these data, the objective lens focal length is between 7.6 and 61 mm. The CCD is normal (24×36 mm) for focal lengths between 37 mm and 300 mm. So, the resulted dimensions (vertical and horizontal) of the CCD sensor can be calculated and their values are given by Eq. (1) and (2).

For scale factor $k = 0.2044$, the vertical dimension is :

$$V = 0.2044 \times 24 \, \text{mm} = 4.9056 \, \text{mm} \tag{1}$$

$$H = 0.2044 \times 36 \, \text{mm} = 7.3584 \, \text{mm} \tag{2}$$

So, the resulted η_F will be 4.9056 mm, value imposed by the minimum dimension (vertical) that limits the field.

The microscope objective lens transforms the object field η_o into an angle field (Eq. 3):

$$w_1 = \frac{\eta_0}{f_{ob}} \tag{3}$$

The small telescope (γ_L) changes the field w_1 in the field w_2 (Eq. 4):

$$w_2 = \frac{\eta_0}{f_{ob}} \cdot \gamma_L \tag{4}$$

Finally, the image field η_F of the digital camera will be given by Eq. 5:

$$\eta_F = \frac{\eta_0}{f_{ob}} \cdot \gamma_L \cdot f_F \tag{5}$$

In the Eq. 5 we considered the obtained values of f_F from the zoom properties of the digital camera. For another value of the f_F out of this range, we can calculate these values, so, it will be in the limits of the digital camera zoom. So, the f_F can be calculated from Eq. 6:

$$f_F = \frac{\eta_F \cdot f_{ob}}{\eta_0 \cdot \gamma_L} \tag{6}$$

For different magnifications of the microscope, Table 1 gives all the necessary values.

Step denotes the magnification step, as marked on the microscope, η_o means the object field, η_F – the image field of the digital camera, f_{ob} – the focal length of the microscope objective lens, f_{oc} – the focal length of the microscope eyepiece, f_{aux} – the focal length of the condenser, Γ – microscope magnification, γ_L – the magnification of the small telescope and f_F – the focal length of the digital camera objective lens.

Table 1

Optical parameters for different magnifications

Step	1	2	3	4	5
η_0	33	20	11.2	6.5	3.5
η_F	4.9056	4.9056	4.9056	4.9056	4.9056
f_{ob}	98.54	98.54	98.54	98.54	98.54
f_{oc}	20.113	20.113	20.113	20.113	20.113
f_{aux}	128.7	128.7	128.7	128.7	128.7
Γ	5.2	9.1	16.0	28.1	49.6
γ_L	0.323	0.569	1.000	1.758	3.100
f_F	45.4	42.5	43.2	42.3	44.6

In this case we can observe that the obtained values of f_F are in the range of 41 – 46 mm for all five magnification steps of the microscope.

The data processing system uses the software EPCO 2000. This software is used to determine the opacity of the posterior capsule (OPC) by the morphological evaluation. The opacity of the posterior capsule is an ordinary complication of the post surgical effect of the crystalline implantation (Fig. 5).
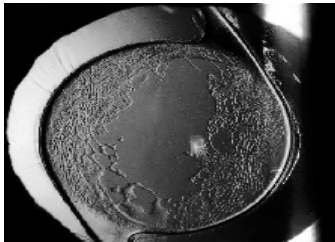

Fig. 5. The region of opacity of the posterior capsule.

Using the pencil/mouse and the color regions the image can be more clearly specified by colors (grey tones in Fig. 6).

Fig. 6. Imagining by colors (greytones here) of the region of opacity of a posterior capsule.

Making some calculations we get the opacity index of the posterior capsule and the ophthalmologist may decide the necessary therapeutic method.

The splitting device enables the following facilities:

- scanning of the crystalline lens; this means the identification of the different regions properties (more or less shone) by colors which are displayed on the screen of the PC; they represent information related to the different parts of the tissue;
- recording of the crystalline lens different regions;
- obtaining of a database for the patients.

CONCLUSIONS

The accuracy of the OPC evaluation is very important in getting more information on the pharmaceutical treatment of the diseases or different surgical types.

Also EPCO 2000 software enables to determine the influence of the different implant types and other factors that occur within the posterior capsule.

By such an instrument every ophthalmologist may follow the evolution of the disease or the post-surgical procedures in such cases as: posterior capsulotomy, iridotomy, etc.

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