A new apparatus of infrared videopupillography for monitoring pupil size

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ABSTRACT

Glaucoma was diagnosed or tracked by the intraocular pressure (IOP) generally because it is one of the physiology parameters that are associated with glaucoma. But measurement of IOP is not easy and consistence under different measure conditions. An infrared videopupillography is apparatus to monitor the pupil size in an attempt to bypass the direct IOP measurement. This paper propose an infrared videopupillography to monitoring the pupil size of different light stimulus in dark room. The portable infrared videopupillography contains a camera, a beam splitter, the visible-light LEDs for stimulating the eyes, and the infrared LEDs for lighting the eyes. It is lighter and smaller than the present product. It can modulate for different locations of different eyes, and can be mounted on any eyeglass frame. An analysis program of pupil size can evaluate the pupil diameter by image correlation. In our experiments, the eye diameter curves were not smooth and jagged. It caused by the light spots, lone eyelashes, and blink. In the future, we will improve the analysis program of pupil size and seek the approach to solve the LED light spots. And we hope this infrared videopupillography proposed in this paper can be a measuring platform to explore the relations between the different diseases and pupil response.

Keywords: Glaucoma, videopupillography, intraocular pressure, pupil, pupil size, pupillometer

1. INTRODUCTION

People usually neglect the symptoms of glaucoma because they are not usually very obvious. We diagnosed or tracked glaucoma by the intraocular pressure (IOP) generally because it is one of the physiology parameters that are associated with glaucoma. But measurement of IOP is not easy and consistence under different measure conditions. The pupil response were discussed in many medical studies [1]-[5]. There are some correlations between glaucoma and the pupil response under the different stimulating light. Therefore, a device to monitor the pupil size is necessary and indispensable to explore the correlations between glaucoma and the pupil response. The pupil size various with the different stimulating light [5]. An infrared Videopupillography is a device to track the location of pupil and to measure and record the pupil size. It is utilized to monitor the pupil response in an attempt to bypass the direct IOP measurement. However, the present videopupillography is large volume and heavy weight, thus it is not convenient to monitor the pupil monitor for a period of time. Thus in this paper, a device apparatus of infrared videopupillography containing several wavelengths of stimulating light is proposed to monitor pupil size for explore the correlations between glaucoma and the pupil response. The infrared videopupillography system is introduced and some experiments is shown.

2. DESIGNS OF INFRARED VIDEOPUPILLOGRAPHY SYSTEM

The Infrared videopupillography system contains stimulating and lighting system, an optical module of beam splitter, a camera, an image software, and an analysis program of pupil size. The flow chart of Infrared videopupillography system is showing as Fig. 1. The command is assigned to MCU by PC-Based software. Than the signal passes to LED driver to control LED. The LED light will light the eye, then the image transfers by the optical module and is record by Camera. Finally, the image is analyzed. The detail are introduced as the following.

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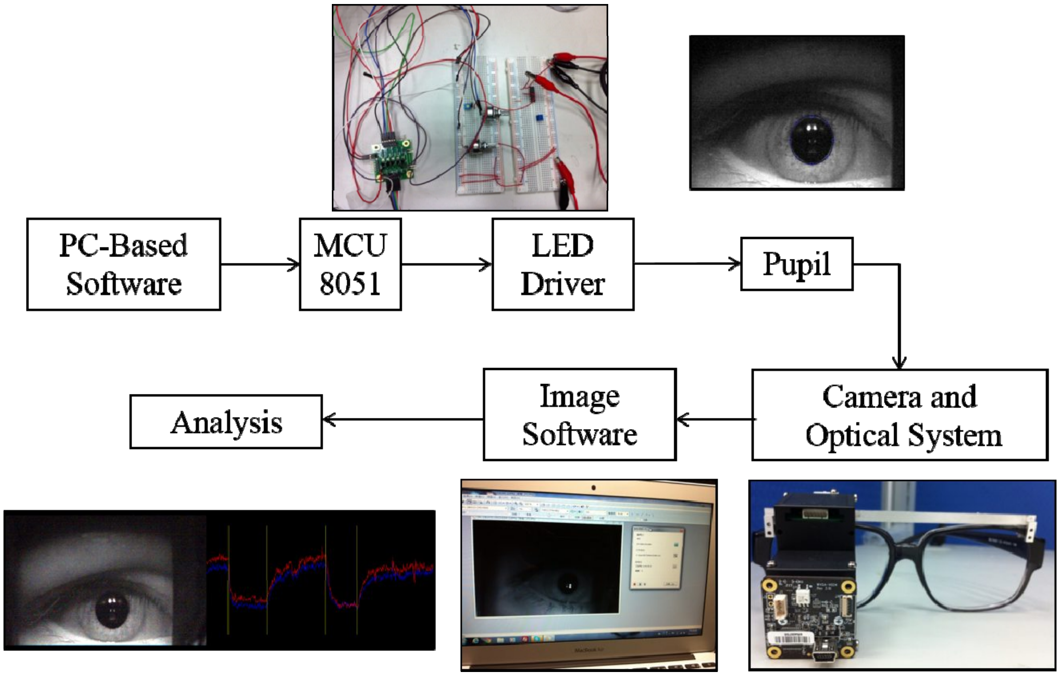


Figure 1. The flow chart of Infrared videopupillography system

2.1 Stimulating and lighting system

The light source of stimulating and lighting system adopts LEDs in this paper. The different wavelength of the stimulating LED are shown as the following: (1) white light, (2) red light (wavelength = 640nm), (3) green light (wavelength = 534nm), and (4) blue light (wavelength = 470 nm). The wavelength of the lighting LED is 900nm, and it will not affect human eye. The LED is controlled with pulse width modulation (PWM). The frequency of PWM is 10 KHz. Their intensity can be modulated by the duty cycle, where the duty cycle is the percent of time that an entity spends in an active state as a fraction of the total time under consideration. The signal is transferred by microcontroller unit (MCU) 8051to control LED driver.

2.2 Optical path and mechanism of infrared videopupillography system

This infrared videopupillography system contains an optical module of beam splitter (BS). It is a longpass dichroic mirror/beam splitter (DMLP900R) [6]. Its transmission and reflectivity at 45° angle of incidence (AOI) are showing as Fig. 2. The transmission is remarked by the blue line and reflectivity is remarked by the red line. 50% Transmission/Reflection is at 900 nm. The visible light form while, red, green, and blue LED reflects at 45° of AOI, and the infrared light has 50% Transmission/Reflection is at 900 nm.

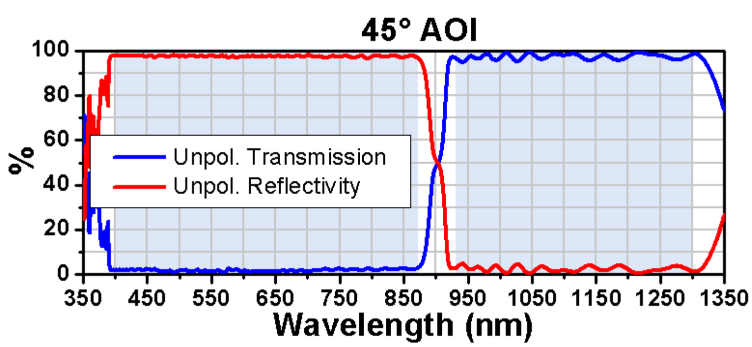


Figure 2. The transmission and reflectivity of longpass dichroic mirror/beamsplitter at 45 angle of incidence (AOI) is shown. The transmission is remarked by the blue line and reflectivity is remarked by the red line. 50% Transmission/Reflection is at 900 nm. [6]

The optical path of this infrared videopupillography system is showing as Fig. 3. The visible light reflects from BS to the eye. Then the reflecting visible light from eye reflects from BS to LED. Moreover, the 50% infrared light of 900 nm passes through BS and is absorbed by the black wall of the module shell. Another 50% infrared light of 900 nm reflects from BS to the eye. The 50% reflecting infrared light from eye reflects from BS to the LED. Finally, another 50% reflecting infrared light from eye passes through BS, then it is imaged by the lens and detected by the camera (1DFM 22BUC03-ML), where the camera resolution is 744*480 and its frame rate is 76 fps).

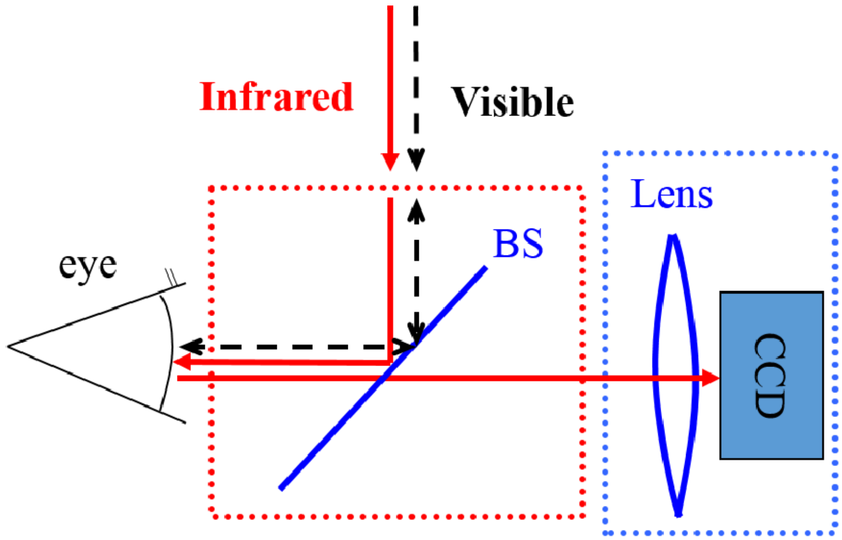


Figure 3. The optical path of this infrared videopupillography system: the visible light is marked by black dotted line and the infrared is marked by red line.

The mechanism of infrared videopupillography system is showing as Fig. 4. Fig. 4 (a) is exploded drawing, and Fig. 4 (b) is assembling picture. The wall of this mechanism shell painted black color to absorb light. The red dotted circle circle in Fig. 4(a) is the furrow to fix the BS. The black circle in Fig. 4(a) is the hole to fix the camera.

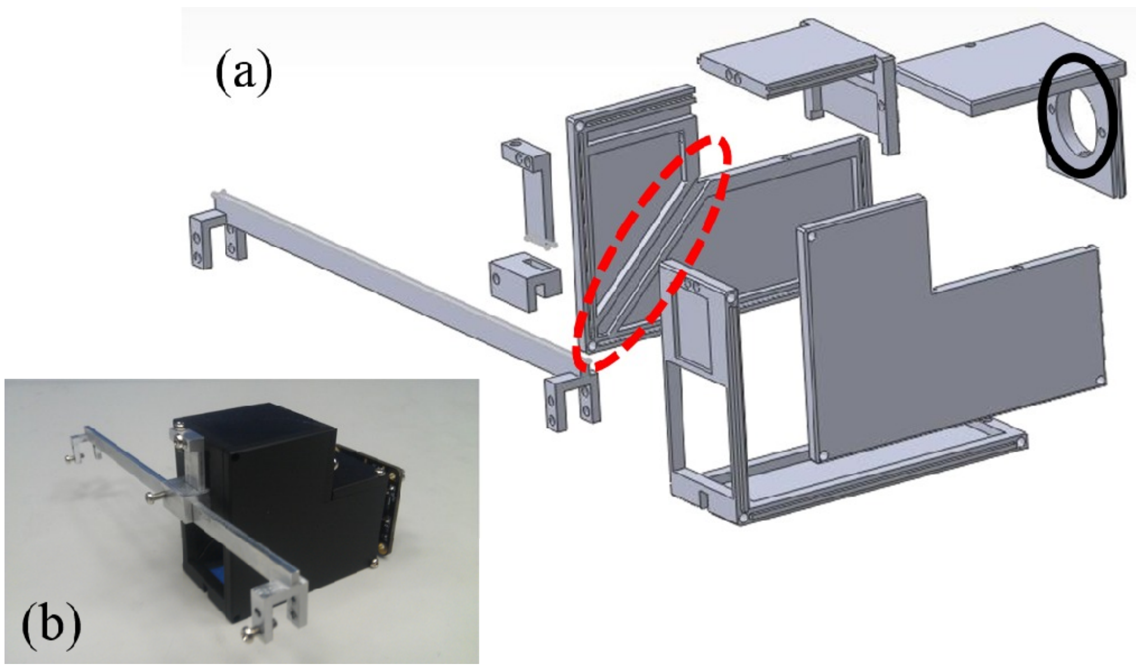
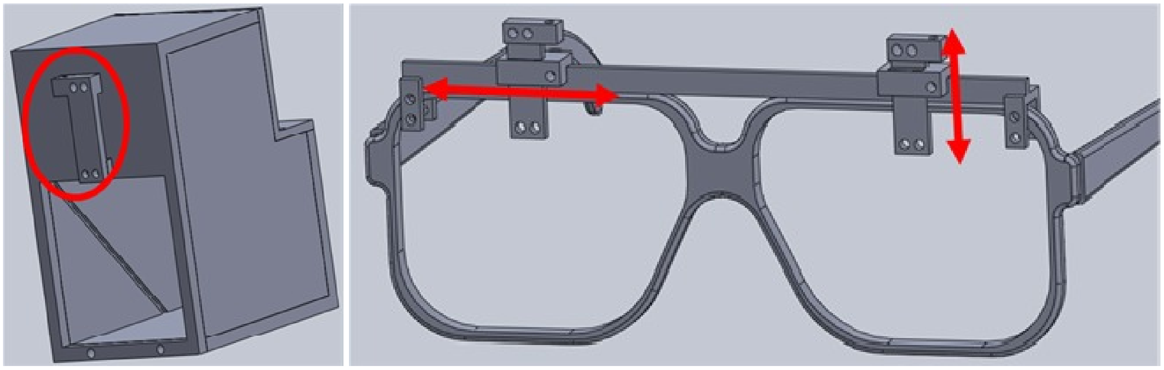


Figure 4. The mechanism of infrared videopupillography system: (a) exploded drawing, and (b) assembling picture.

Moreover, the mechanism of infrared videopupillography system can be modulated on the eyeglass frame as Fig. 5 showing. The structure in Fig. 5 (a) can fix on the brace that can modulate the location in vertical direction as Fig. (b) showing. And the brace on the rail can modulate the location in horizontal direction.



(a) (b)

Figure 5. The mechanism of infrared videopupillography system can be modulated on the eyeglass frame. The structure (a) can fix on the brace (b) that can modulate the location at both vertical and horizontal direction.

2.3 The analysis program of pupil size

The pupil video is captured by the video capture card. The pupil images are extracted from the pupil video, then they will be processed with the following steps as Fig. 6 showing. First, the image load from the extracting images, and process as the gray images. We set the maximal search rage of pupil size and the rate of semi-major axis and semi-minor axis. The appropriate oval will be search by image correlation. The eye diameter of major axis and minor axis of all images will be obtain. Finally, we can obtain the variation of eye diameter of major axis and minor axis in this pupil video.

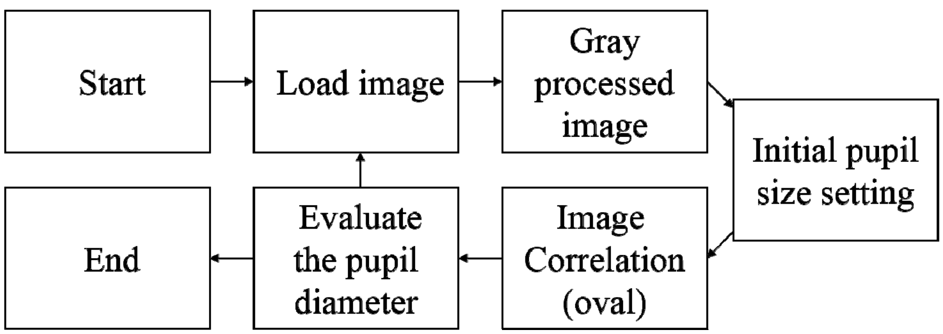


Figure 6. The flow chart of the analysis program of pupil size

3. EXPERIMENTS

The picture of infrared videopupillography system in the experiments is showing as Fig. 7. The eye images obtained from the video are showing as Fig. 8. Fig. 8 (a) is pictured without stimulus, we find the pupil is bigger and there are two infrared light spots at the upside of pupil. Fig. 8 (b) is pictured with stimulus, we can find the pupil contract, and there are two infrared light in the upside of pupil and one visible light spots in the middle of pupil. When the subject eye stimulated by the green light of 50 Hz, 500 mcd. One cycle of LED stimulus have 8 seconds of stimulus and 15 second of rest. The eye diameter curves of major axis and minor axis are showing in Fig. 9 and marked with blue and red lines respectively. This two curves are not smooth and jagged, and this results caused by the infrared light spot, eyelashes, and blink. Because the infrared light spot and long eyelashes will affect the accuracy of the oval image correlation, and there is no data when the subject blinks.

Figure 7. The pictures of infrared videopupillography system in experiments

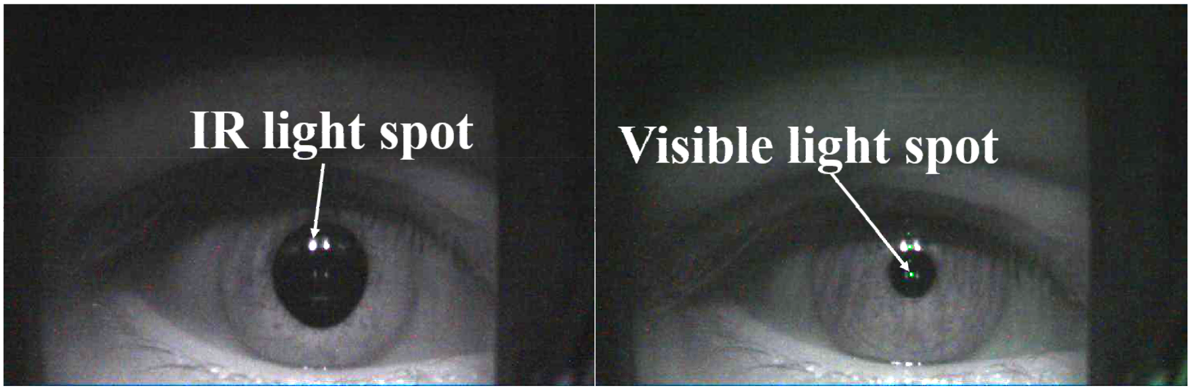


Figure 8. The eye images obtained from the video: (a) is pictured without stimulus. The pupil is bigger and there are two infrared light spots at the upside of pupil. (b) is pictured with stimulus. The pupil contract and one extra visible light spots appear in the middle of pupil.

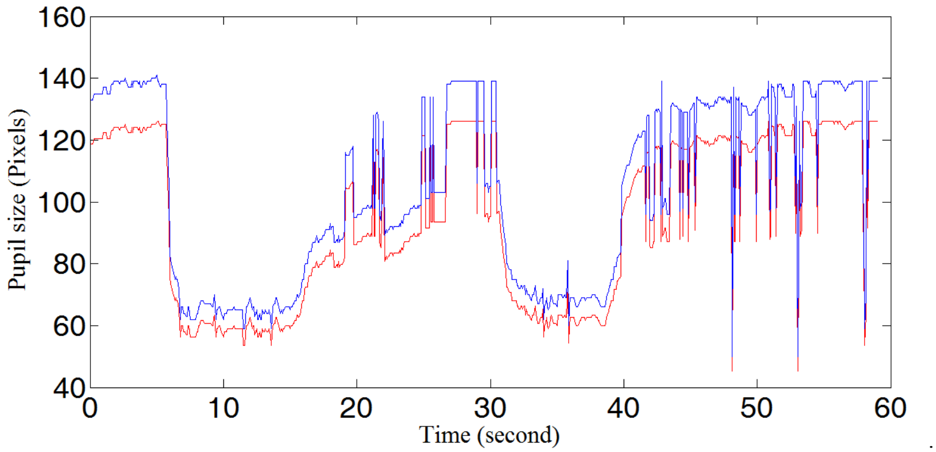


Figure 9. The eye diameter curves of major axis and minor axis marked with blue and red lines respectively

4. CONCLUSIONS

This paper proposed a new apparatus of infrared videopupillography with several visible light of LED to monitoring the pupil size. It is lighter and small than the present product, and is applied to explore the correlations between glaucoma and the pupil response. Beside, an analysis program of pupil size is used for evaluating the pupil size automatically. But the eye diameter curves of major axis and minor axis were not smooth and jagged, and it caused by the infrared light spot, eyelashes, and blink. The algorithm of pupil size analysis will be improved, and the approach to solve the LED light spots will be sought in the future.

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