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Brightness controller optimization for the digital diaphanoscopy system

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Abstract: In this work, the LED applicator brightness control unit of the digital diaphanoscope was upgraded, which allows adjusting of the radiation power value in a wide range for patient's study, considering anatomical and gender features.

1. Introduction

Previously conducted studies on conditionally healthy volunteers and patients with suspected maxillary sinus pathology, as well as numerical modeling of the passage of optical radiation through the maxillary sinus of male and female with various pathologies, revealed the influence of their gender and anatomical features on the recorded pattern of light scattering. It showed the need to refine the digital diaphanoscope in order to obtain similar scattering patterns [1-2]. For this aim, the LED applicator brightness control unit was designed [1], to adjust the power emitted by the LED applicator for different patients, based on its gender and anatomical features [3].

During the research, using the LED applicator brightness control unit, the values of the optical radiation power in the range from 1 to 18 mW (the maximum permissible value of the change in the optical radiation power for LEDs with a wavelength of 650 nm) were determined using the control panel for the power meter PM400 (Thorlabs, Inc.) and the photodiode sensor S120VC (Thorlabs, Inc.). It was noted that in male volunteers, the value of the radiation power of 18 mW was not sufficient to obtain an adequate scattering pattern of light passing through the sinuses, which is related with the anatomical features of men (the thickness of bone tissue, skin, size of the sinuses) [1, 4-10].

Thus, the aim of this study was to modernize the previously developed LED brightness controller to allow changing the power of optical radiation in a wider range and to determine the required power value for the diagnosis of male patients.

2. Material and methods

To solve the problem with a lack of the maximum power of optical radiation was conducted additional analysis of the elements of the developed device, on the basis of which revealed the need to change the nominal value of the resistor in the circuit current limiting built on the basis of the linear adjustable stabilizer LM350T, as it is this circuit was observed a discrepancy between current values indicated in the documentation for the LEDs.

Analysis of the main technical characteristics of LEDs with wavelengths of 650 nm (C4L-H12T5) and 850 nm (F3453) by OSRAM Opto Semiconductors GmbH (Germany), showed that the maximum power supply current of LEDs for F3453 is 0.1 A, for C4L-H12T5 is 0.07 A. Taking into account these parameters, the necessary resistance values of the resistors in the current limiting circuit were determined, and their selection was carried out. This made it possible to change the optical power in a wider range.

Using the upgraded adjustment unit, studies were conducted with the participation of conditionally healthy volunteers (10 women and 10 men) in order to establish the optimal values of the optical radiation power for each subject based on its anatomical and gender features. At the same time, in order to select the required value of the radiation power, for each test subject, the value of the body mass index (BMI) was calculated. The BMI is associated with the fatness of patients [11], which directly affects the recorded scattering pattern of light [2].

During the study, the values of the brightness control unit were selected sequentially from 0 to 250 a.u. in increments of 50 a.u. The relationship between the controller values and the LED optical power is shown in Table 1.

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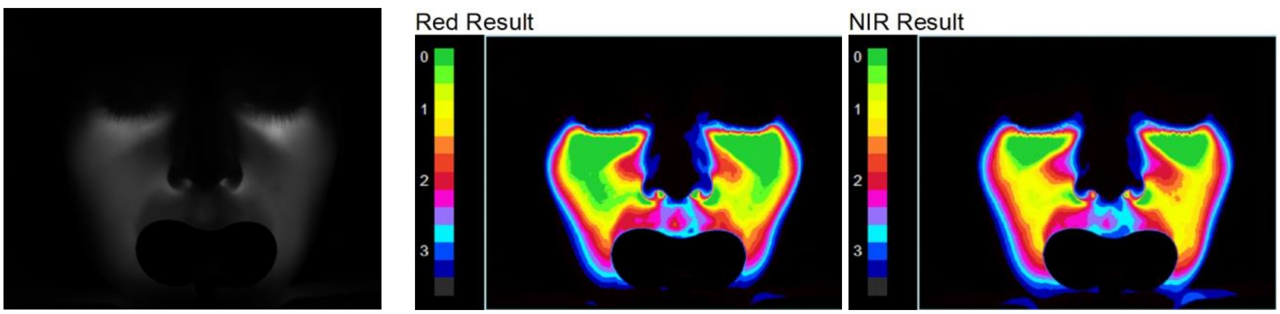
Table 1. The range of the set values of the optical radiation power.

Controller value, a.u.	Optical power (650 nm), mW	Optical power (850 nm), mW
0	25	5
50	35	25
100	40	65
150	50	83
200	55	84
250	60	84

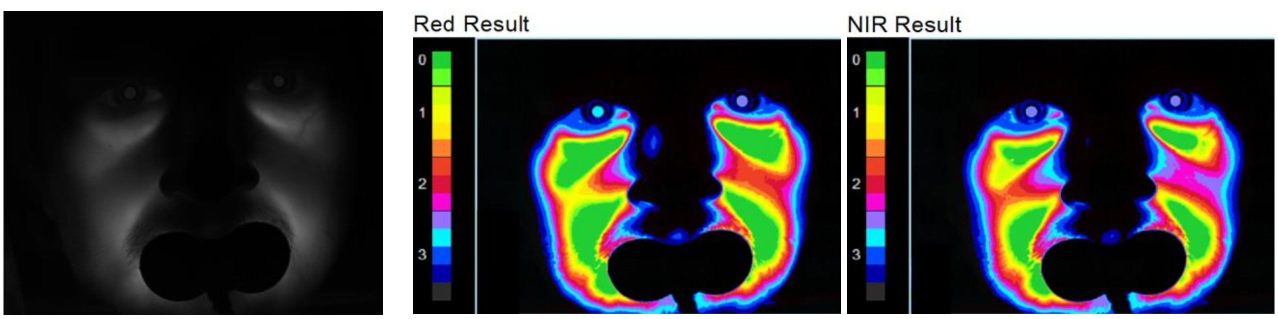
3. Experimental results and discussion

Examples of recorded light scattering patterns are shown in Figures 1 and 2 for women and men, respectively.



a b

Fig. 1. Example of the recorded scattering pattern of light (a) and the result of digital processing image (b) for female. The controller value is 50 a.u., the camera exposure time is 40 ms.



a b

Fig. 2. Example of the recorded scattering pattern of light (a) and the result of digital processing image (b) for male.The controller value is 250 a.u., the camera exposure time is 60 ms.

The obtained results showed the correlation of the selected value of the optical radiation power with the gender of the volunteer. So, in the study of female volunteers, the maxillary sinuses were well visualized at the controller value of 50 a.u. and a camera exposure time value of 40 ms. In the study of male volunteers, the required power was equal to 250 a.u., while increasing the value of the camera exposure time to 60 ms.

Note that at this stage, volunteers with the BMI in the normal range (from 18.5 to 24.9) were studied [12]. To identify the correlation between the values of the BMI and the value of the selected optical radiation power, a sample of other types of volunteers (underweight, overweight, and obesity) will also be recruited in the future. This will allow to form the requirements for choosing the value of the optical radiation power.

Based on the obtained data, further studies will be conducted on patients with suspected maxillary sinus pathology, as well as refined mathematical modeling using the established values of radiation power for male and female in order to establish medical and technical requirements.

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