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Development of the Miniaturized Iris Diagnosis System with Inherent Artifact Free

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ABSTRACT

Iris diagnosis based on the color and texture information is one of a novel approach which can represent the current states of a certain organ inside body or the health condition of a person. In analysis of the iris pattern information, there are critical image artifacts which can prevent of use interpretation of the iris texture images. Here, we developed the light artifact free iris diagnosis system with a hand-held typed imaging probe at a low cost which consists of a single camera sensor module with 8M pixels, two pairs of white light LED module with a bandwidth of 400~700 nm, and a guide beam. Two original images with two different light noise patterns were quickly, successively acquired in turns, and the light noise-free image was finally reconstructed by the proposed artifact removal approach including both hard- and software.

Key words : hand-held probe, light Artifact removal, Image reconstruction, Iris diagnosis

1. INTRODUCTION

Medical analysis of human eye information has been widely used to diagnose specific diseases and a health state of a human body. Especially, iris diagnosis, iridology, using a color and texture information of a iris organ is one of a novel approach which can represent the current state of a certain organ inside body or the health condition of a person [1,2]. It can play an important role for prevention and treatment of illness, for maintaining a good health condition before the illness comes to the breakout. The Iris diagnosis (Iridology) has been widely employed in many countries as a complementary-medicine discipline. With decades of scientific observation and comparative studies, it is known that the iris is the only externally visible organ that can reflect metabolic disorders like diabetes, a condition of pancreas and liver organs as a map of body [1,3,4]. In addition, several scientific studies have reported that the iris features correlate with the personality, the personal behavior, and the depressive illnesses [5,6]. Therefore, the iris analysis can substantially influence on the area of medicine and sociology as well. In reality, the iris recognition technology has been remarkably developed in the area of the security for the personal identification up to date

[7]. However, the iris diagnosis requires more accurate resolution and evaluation approaches compared over the conventional iris recognition technologies.

In analysis of the iris texture information, there are critical image artifacts which can reduce the performance of both the iris recognition and diagnosis systems such as a light reflection on a cornea surface [7,8]. Those artifacts prevent of use interpretation of the iris textures on images due to a shadow region under a light reflection. Hence, for exact texture information the image processing technologies are essential to remove those image artifacts [9,10].

In this study, we developed the miniaturized iris diagnosis system with the removal algorithm of a light reflection artifact at a low cost. The system is based on a hand-held typed probe which consists of a commercialized RPI camera sensor module, two pairs of a white light LED, and a guide beam to capture and display the human iris images in real time. Two original images with different light reflection positions are captured quickly, successively in turns and, as a result, the final iris image with a light source noise free is reconstructed through several image processing steps: gray scaling, pre-masking, range setting, matrix dilation, and registration.

2. EXPERIMENTAL SET UP

Figure 1 represents the entire system configuration for the light artifact-free iris texture image. The system based on a hand-held typed imaging probe consists of a single camera sensor module with 8M pixels (RPI V2), two pairs of a white light LED with a broadband of 400 ~ 700 nm, and a guide beam to fix a human eye ball position physically. For synchronization of an optical source and a camera sensor, and for image preprocessing, we employed Raspberry Pi 3 compute tool kit module as a core engine and running software of Python 2.7.13.
The hand-held typed imaging probe was designed to have a proper imaging working distance mechanically so that it can acquire and visualize the iris image clearly on the monitor in

real time display. Each pair of a white light LED positioned diagonally as shown in Figure 2. is irradiated onto an eye with an angle of ~45 degree. We used a guide beam with a visible range wavelength to fix the iris position physically in a valid region of an effective image processing since it is difficult to place the light reflection pattern on the same position due to motion artifact. Even if we employed an additional guide beam, the total optical power incident onto a cornea is within ~1mW which meets the safety requirements set by the American National Standards Institute (ANSI) Z136.1 limits [11].

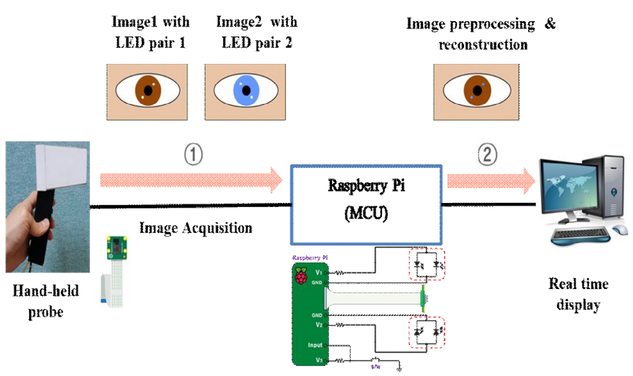

Figure 1: Schematic of the miniaturized iris system for the light artifact removal

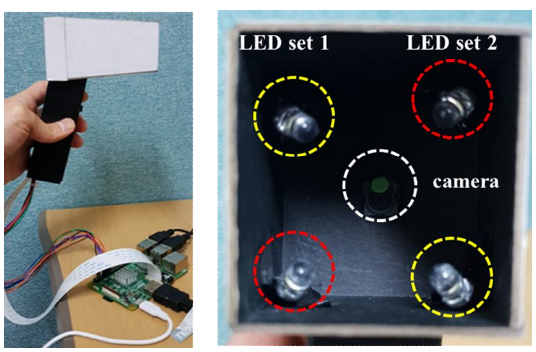

Figure 2: Hand-held imaging probe configuration

3. IMAGE PROCESSING APPROACH

The light reflection artifact removal algorithm can be explained briefly as shown in Figure 3. Two original color images with two different light reflection patterns from two pairs of LED (the yellow dot circle indicating the LED set1, the red dot circle indicating the LED set2 in Fig. 2.) are obtained successively in turns.

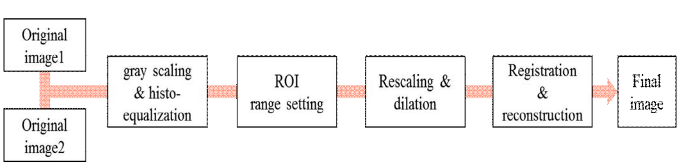

Figure 3: Image processing algorithm for a light artifact-free

In the first step, image1 is converted into a gray scale format with a pertinent threshold value and processed by the histo equalization. Based on analysis, a threshold value can be determined as an averaging value of a and b factors, a is a value beginning to recognize the light noise on the image, b is a value beginning not to recognize the light noise on the image. The final threshold value was determined to be 175 after averaging all threshold values extracted from the images of 10 subjects.

In the Second step, the light noise of two LEDs can be a region of interest and selected by the pre-mask based range setting steps. Pre-masking circle size smaller than the whole iris includes the pupil and excludes a region out of the iris all the time, and all the light artifact patterns induced by two pairs of LED are included within this pre-masking circle due to a guide beam.

In the third step, to remove the light noise sufficiently, the light noise removal region, ROI, can be expanded as the dilation step by using 5x5 matrix parameters of the conventional adaptive kernel filter. This matrix parameter can be determined by averaging all the values extracted from the acquired images of 10 subjects. Finally, the ROI on the image1 can be replaced with the corresponding ROI of the image2 so that the final image can be also reconstructed without the light source artifact.

4. RESULTS AND DISCUSSION

Figure 4 (c) shows the images resulted from the proposed artifact removal process. Acquired original image1 with the light artifact and the pre-mask (a green circle) shown in Fig. 4 (a) is converted into a gray scale format image with a proper threshold. Pre-mask can be set up to have the proper circle size and include the LED noise all the time because patients always see a visible guide beam during imaging process. In addition, operator can instruct for a patient eye to be placed into a green circle through a monitor.

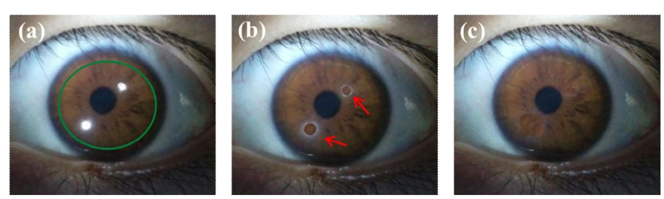

Figure 4: Original image1 with a light noise and a pre-mask (green circle) (a), image with another blurred mask noise by a dilation step, reconstructed artifact-free final image (c)

To remove the light noise sufficiently, the light noise removal region, ROI, can be selected and expanded as the dilation step by using 5x5 matrix parameters of the conventional adaptive kernel filter. If there is not the dilation step, the image can have another blurred mask noise indicated by the red arrows shown in Fig. 4 (b). Furthermore, we overcame the intensity difference issue of two original images via the histo-intenstiy matching compensation.

The light noise free final image can be reconstructed and demonstrated as shown in Figure 4 (c). The invisible texture information under the LED light artifact is clearly visualized in the reconstructed final image of Fig. 4 (c).

Based on analysis of the iris texture information, the invisible iris texture under light noise of the original image1 as shown in Fig. 5 (b) and 5 (c) are clearly seen in the reconstructed final image shown in Fig. 5 (h) and 5 (i). The ROI with a light noise of the image1 was replaced appropriately with the corresponding ROI of the image2, and we can find out the iris textures in magnified images of Fig. 5 (e) and 5 (f) are the same as them in Fig. 5 (h) and 5 (i). The whole imaging region and ROI of two images are always the same because of the imaging speed much faster than it of the eye movement and a single camera sensor. However, ROI was not perfectly reconstructed and slightly different from the surrounding regions of ROI as shown in final images of Fig. 5 (h) and 5 (i). Hence, in the near future, the final image should be compensated by additional intensity correlation and spectral matching algorithms.

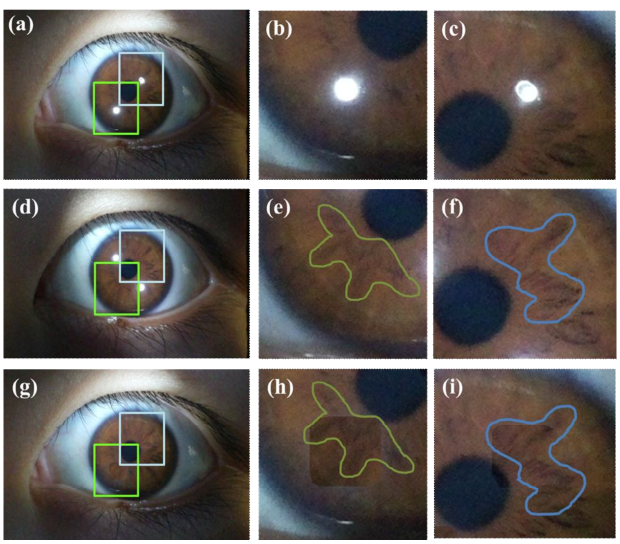

Figure 5: Original image1 (a), magnified ROI with a light noise of original image1 (b) (c), original image2 (d), magnified ROI of original image2 (e) (f), the reconstructed final image (g), magnified ROI with visible iris texture information of the final image (h) (i)

In this study, we developed the miniaturized iris diagnosis system based on a hand-held probe at a low cost, which can enhance the flexibility and usability of the system performance in various environmental conditions compared with the conventional chin-rest based system. For more accurate and of use interpretation of the iris texture image, we removed the light artifact on the original images effectively through the proposed preprocessing approach including both hard- and software. All of image processing parameters were determined from the iris images of 10 subjects. We demonstrated successfully the light artifact free final image, and the invisible texture information of the original image1 is clearly seen in the final image even if the ROI is not perfectly reconstructed.

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