Non-contact Hand Vein Imaging by Use of Aerial Guiding Illumination with AIRR

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ABSTRACT

We propose a novel optical system aimed for non-contact hand-vein input. A floating aerial image is formed to guide a user's hand to the focused position and to illuminate the hand for vein imaging. We can install a camera in the illumination optics because of the high NA of AIRR.

1 INTRODUCTION

In recent years, biometric authentication based on vein pattern is introduced to high security interfaces such as an automatic teller machine (ATM) and building entry/exit managements. In these interfaces, there are a risk of fingerprint leakage and a hygiene issue because of contacting its touch panel. There is also a problem of the low throughput on hand vein input. Because a high throughput is required at admission control of concert venues, a prototype system that performs vein authentications using images of moving hands has been proposed [1]. In order to obtain a clear vein image without contact, it is necessary to use a lens of small F-number. Therefore, the depth of field is narrow, and it is difficult to place the hand on the imaging position with non-restriction.

The purpose of this paper is to propose a novel optical system for non-contact hand vein imaging. Our proposed system employs an aerial image formed with aerial imaging by retro-reflection (AIRR) [2]. The aerial image has two functions: (1) guiding a hand to the focused position in the mid-air and (2) illumination for hand vein detection. Because AIRR features a high NA converging light, we can place a hyper-spectral camera in the center of the AIRR setups. Furthermore, we have realized several types of aerial guiding illuminations to compare the usability for the hand vein input.

2 PRINCIPLE

Fig. 1 shows the principle of AIRR. The light from the light source is split into transmitted light and reflected light by the beam splitter. A part of the light impinges the retro-reflector and is reflected reversely to the incident direction. Retro-reflected light converges to the position of the plane symmetry of the light source with respect to the beam splitter.

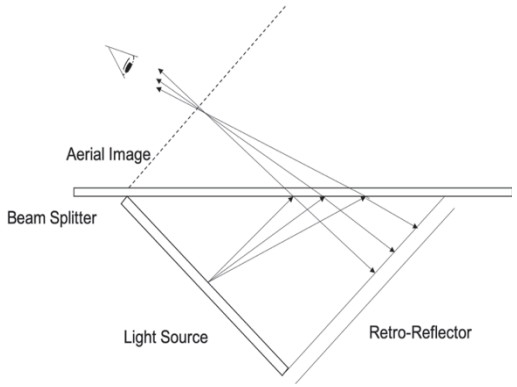


Fig. 1 Principle of AIRR.

Fig. 2 shows our proposed optical system. An advantage of this optical system is the point which an object can be placed between the light source and the aerial image. A camera is installed right under the aerial image to capture the hand vein clearly. The optical system consists of an imaging device, a beam splitter, a light source, and a retro-reflector.

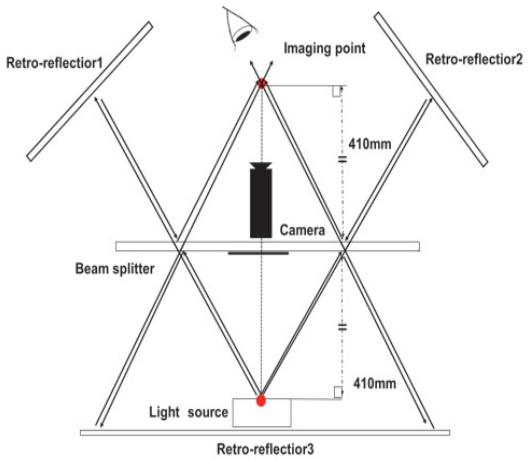


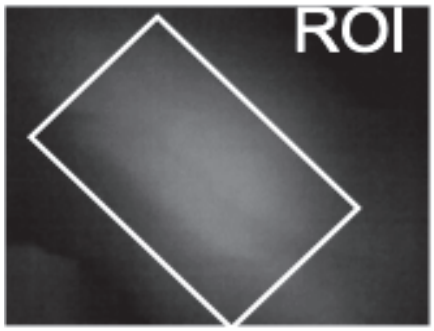
Fig. 2 Optical system for aerial guiding illumination.

3 EXPERIMENTS

A hyperspectral camera (EBA JAPAN Co., Ltd., NH-7) acquiring spectral images from 350 nm to 1100 nm is

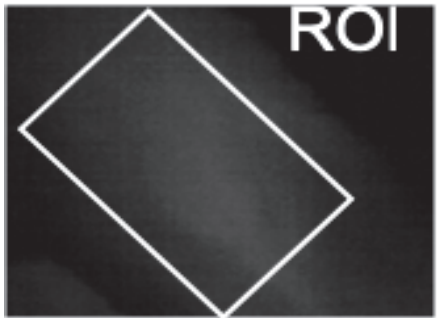
used as the imaging device. As a light source, we use a solar simulator (Asahi Spectra Co., Ltd., HAL-320), which covers the measurement wavelength band. The principle of forming an aerial image is the same as the AIRR.

Fig. 3 and Fig. 4 show examples of spectral images of a hand. Hand vein pattern was clearly detected when the hand was placed at the focused position. Thus, how to guide a hand to the focused position is one of the important issues on non-contact hand vein input system.



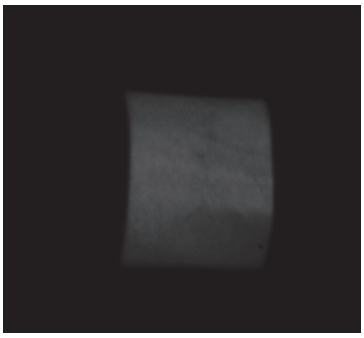
(a) 500mm below aerial guide. Image obtained from the hyper spectral camera.
[650nm, Frame rate:20, Gain: 50]

(b) on the aerial guide.
[650nm, Frame rate:20, Gain: 50]

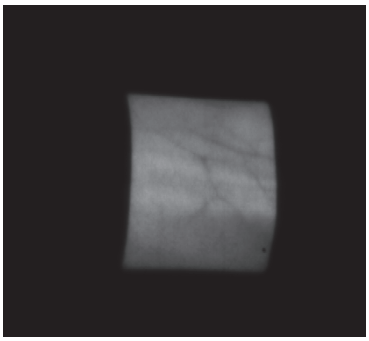


(c) 50mm above the aerial guide. Image obtained from a hyperspectral camera
[650nm, Frame rate:20, Gain: 50]

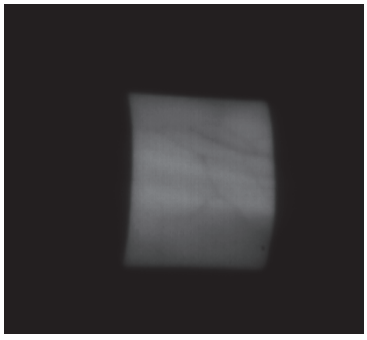
Fig. 3 Spectral images of vein illuminated by our aerial guiding illumination.



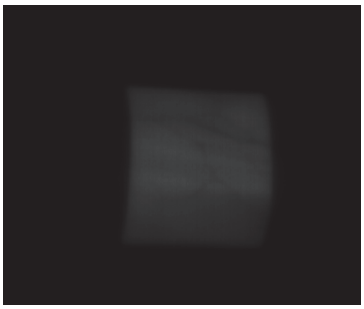
(a) 500nm



(b) 600nm



(c) 700nm



(d) 800nm

Fig. 4 Spectral images of vein illuminated by our aerial guiding illumination acquired every 100nm wavelength.
[Frame rate:10, Gain:50]

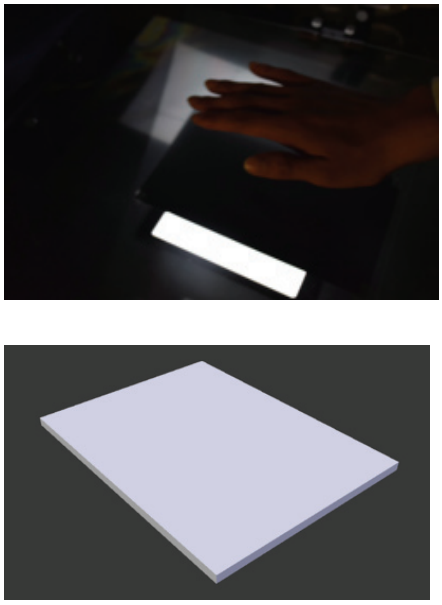


Fig. 5 Guide Illumination of a white flat plane.

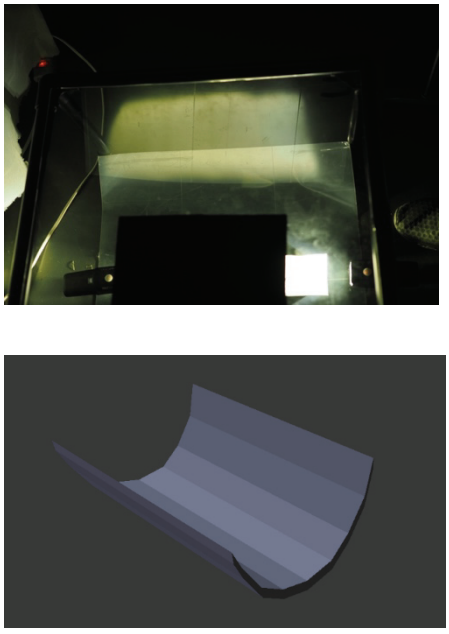


Fig. 6 Guide Illumination of a plate that bents Type 1 along the shape of the arm.

We have realized four types of aerial guide illumination for comparison. In Type 1, a white flat plane is formed at the imaging position. The prototype of Type 1 is shown in Fig. 5, where a hand is placed on the aerial image.

In Type 2, a plate that bents Type 1 along the shape of the arm. Type 2 prototype is shown Fig. 6. Type 2 is a guide light that guides you to put hand along the curve.

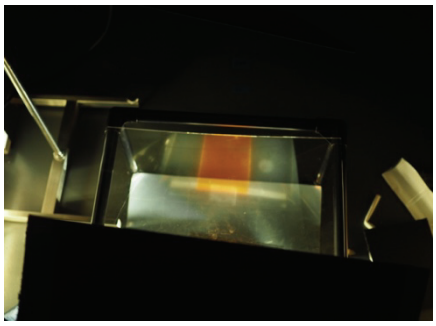


Fig. 7 Guide Illumination of two-layered boards.

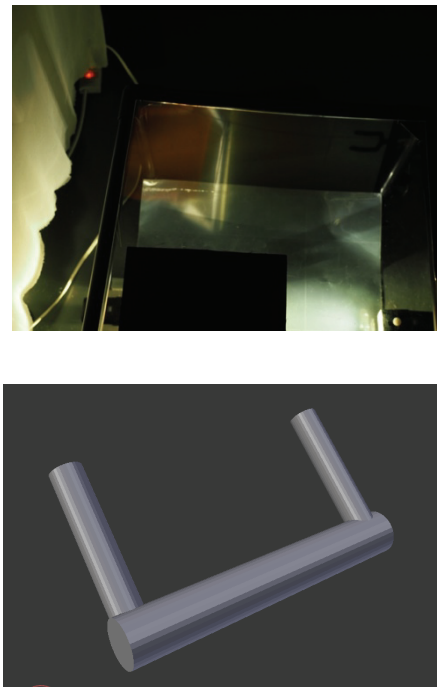


Fig. 8 Guide Illumination that operates a grip.

Type 3 consists of two-layered boards. Its prototype is shown in Fig. 7. Type 3 is designed to guide a hand to the imaging position by putting the hand between the two boards.

In Type 4, aerial guide illumination is formed at the imaging position to induce a user to grip the aerial guide. Its prototype is shown in Fig. 8. The aerial image of the grip is formed in the mid-air.

4 DISCUSSION

Conventional biometric authentication has information leakage such as fingerprints and hygiene problems. However, the problem was improved by using the aerial image as a guide. A new problem of handling an aerial image as a guiding illumination is that it may not be possible to grasp the distance from the aerial image. It is thought that there is a difference in the position recognition ability because the position judgment path is different between the case of placing the hand by recognizing the position of the aerial image only with the eyes and the case of position of the aerial image while instructing the movement.

Our preliminary experimental results show that the aerial guiding illumination performs to limit the degree of freedom in placing a hand. For example, Type 1 and Type 3 only guide the distance and do not limit the position and direction of hand in the imaged plane. Type 2 guides the distance and direction of a hand. Type 4 guide the distance, the direction, and the position of a hand. Thus, Type 4 has a high repeatability in the measurements.

Further usability tests will be needed including the throughput and accuracy of vein authentication.

5 CONCLUSION

We have proposed a non-contact and non-restraining vein imaging optical system by use of an aerial image. The aerial image is used as a guide illumination to navigate a hand to the imaging position. In addition, since the effectiveness of the aerial guiding illumination may change depending on the aerial image to be formed and the instructions to it, prototypes for comparison have been developed and examined. A grip-like guiding illumination performed better navigation of a hand.

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