THERMAL-ID: A PERSONAL IDENTIFICATION METHOD USING BODY TEMPERATURE

Itaru Kitahara, Masami Ito, Haruo Noma,

Kiyoshi Kogure and Norihiro Hagita [1])

Abstract

We propose a novel personal identification method, named Thermal-ID, which utilizes human body temperature as a source of identifying information. Thermal-ID is expressed by the temperature difference generated by partially covering the surface of the body with thermal barrier material (e.g., cutout urethane foam-coated aluminum foil). The aim is to positively identify a subject with minimal disturbance to his/her activities. The AR Toolkit is employed to extract the subject's identification information to determine the Thermal-ID with image processing. The effectiveness of the method is shown by introducing the pilot system under development.

1. Introduction

The recent deterioration of public safety is causing serious concern. One of the most promising contributions of pervasive computing technology is to understand what is going on in the real world, and indeed many systems are being developed for this purpose [1]. Personal identification is regarded as an especially important issue to achieve a safe and secure society [2]. Personal identification approaches can be roughly categorized into two types. One of them, which is called the active approach, install special equipment that transmits an identifying code into specific objects. RF (Radio Frequency)-ID (Identification) tags or LED (Light-Emitting Diode)-ID tags are now used as such communication media [3][4]. The other approach, called the passive approach, extracts identification information using environmentally-fixed sensors such as video cameras and microphones [5][6]. The active approach has an advantage in that it positively identifies the observed objects. However, in some circumstances (e.g., nursing services), it is difficult to attach transmitting equipment to the observed objects, because attaching the equipment and connecting the cables might disturb the nurses' working activities. In contrast, the passive approach does not impose such a physical burden. However, this approach demands a predefined procedure (e.g., fingerprinting, iris scanning) from the observed people. The interruption caused by the predefined procedure might also upset them.

We are working toward solutions to the above problems and are developing a novel personal identification method, named Thermal-ID, which utilizes human body temperature as a source of identifying information. This method focuses on two properties, one of which is that human body temperature is generally higher than the environmental temperature. The other is that we usually wear some clothes on the upper body. The Thermal-ID marker, the identifying code, is expressed by the temperature difference generated by partially covering the surface of the body with thermal barrier material.

[1] ATR Intelligent Robotics and Communication Laboratories, (http://www.irc.atr.jp/)
Hikaridai 2-2-2, Keihanna-Science City, 619-0288, Kyoto, Japan

2. Personal Identification Method Using Body Temperature

Our personal identification method aims to positively identify a subject with minimal disturbance to his/her activities. An overview of the proposed method is illustrated in **Fig. 1**. The system captures the subject who wears Thermal-ID embedded clothes with an infrared (thermal) camera, and extracts the identification information from the thermal image with image processing. In contrast with identification equipments to emit electric waves or light, Thermal-ID makes us free from taking care of battery life. Since Thermal-ID transmits ID information by body temperature that is radiated from our body as long as we live. In such matter of battery power, passive RFID possess the similar characteristics as our proposed method. However, the coverage area of passive RFID is not so large. To the contrary, Thermal-ID can identify the target object regardless of the sensing distance, as long as the thermal camera captures the ID tag. Additionally, the proposed method utilizes invisible temperature as a source of identifying information, so, it is possible to guard the secrecy of privileged or administrative information from outsiders.

2.1. Thermal-ID Marker

The two-dimensional bar-code typified by QR-code is a well-know medium [7]. The two-dimensional bar-code is described with a fine black and white waffle pattern. However, the infrared radiation the system uses is much weaker than visible light. Thus, it is difficult to scan such fine patterns in thermal images. Our system expresses identifying information using the AR Toolkit, which is being developed in the research field of Augmented Reality (AR) [8]. With this toolkit the user can arbitrarily set the size of a two-dimensional marker to correspond to the resolution of the capturing infrared camera. Since the toolkit can handle such scannable characters as a two-dimensional marker (e.g., alphabet, digit, or symbol), it has another merit in that user can easily monitor the operation with their own.

As shown in

Fig. 2, the two-dimensional markers of Thermal-ID are shaped by cutting out urethane foam-coated aluminum foil. We place the cutout foil on the human body to block off bodily heat. Consequently, there is a temperature difference between the covered region and uncovered region, and that difference causes changes in the intensities in the captured infrared image. The system extracts the subject's identification information to determine the two-dimensional marker's identity using the changes in intensity.

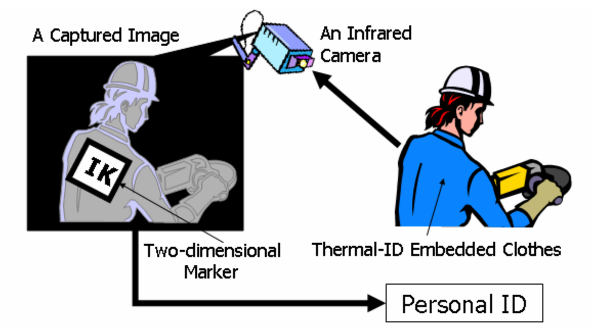

Fig. 1. Overview of "Thermal-ID" Identification System

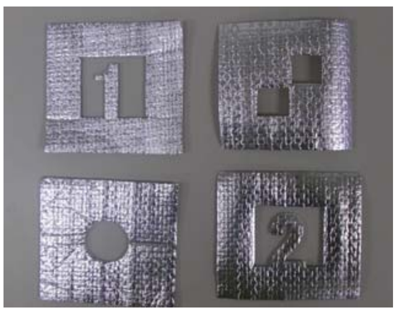

Fig. 2. Examples of Two-Dimensional Marker of Thermal-ID Marker

2.2. Extracting Identification Information from Thermal Image

The AR Toolkit provides a function to detect the two-dimensional marker from the input image. With this function it is possible to automatically extract the identification information. However, our proposed method still has a problem; the AR Toolkit assumes the visible light image as the input information. On the other hand, we capture and input the infrared image as the input. Since infrared radiation is much weaker than visible light, the contrast ratio between the region of the marker and the region of the body surface might not be enough for the AR Toolkit's detecting function. We solve this problem by preprocessing the input infrared image to enhance contrast.

When detecting the two-dimensional Thermal-ID marker, the contrast of the foreground region is more important than that of the background. We enhance the contrast of only the foreground region with the following steps. (1) Segment the input image into foreground and background regions. In our proposed method, the capturing camera is assumed to fix on the environment. Therefore, a background subtraction operation is available. (2) Survey all pixel values in the foreground region to detect the maximum value *Imax* and the minimum value *Imin*. (3) Enhance the contrast of the foreground region to calculate the normalized pixel values *I* from *Iorg* with Eq. (1). In this case, we express the pixel value with an 8 bits gray-scale.

$$I = (I_{org} - I_{\min}) \times (255 / I_{\max} - I_{\min}) \qquad (1)$$

Fig. 3 shows the effectiveness of the preprocessing to enhance the contrast of the foreground region. The left window is the result when the contrast enhancement operation is not applied. The system fails to detect the two-dimensional marker, because the contrast ratio is not sufficient. In the right window, we apply the preprocessing to the input infrared image. As a result, the marker is successfully detected. The edges of the extracted marker are highlighted by the green and red lines. As a simple operation check, this system has a mapping table that describes one-to-one correspondence between identification information and color. On the interface, we can confirm that the identification information is extracted with the small light-blue box displayed at the lower-left of the right window.

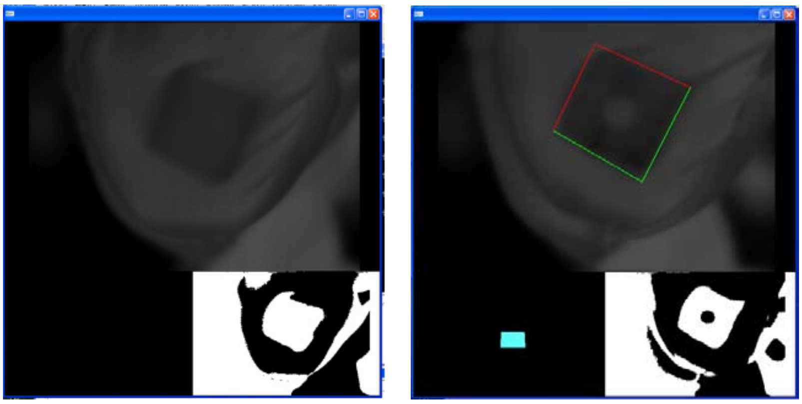

Fig. 3. Result of the Contrast-Enhancement Operation

3. An Application System of Thermal-ID

A pilot system that applies our proposed personal identification method is shown in

Fig. 4. This system gives a Web browser a new expanded function. The user wears Thermal-ID-embedded clothes and starts up the function-expanded Web browser while being captured by an

infrared camera. The system processes the input images to extract Thermal-ID. If the extracted ID corresponds to the user's pre-registered personal information, the system provides the user with some services via the Web browser interface. For example, an automatic jump to a favorite Web site or automatic password input for certification proceedings (the URL address and the password are pre-registered).

Fig. 5 is a screenshot of the function-expanded Web browser. You can see that our proposed personal identification method positively identifies subjects without disturbing their activities.

4. Conclusion

We proposed a novel personal identification method, called Thermal-ID, which utilizes human body temperature as a source of identifying information, and showed the effectiveness of the method by introducing a still-developing pilot system. We currently assume that the two-dimensional marker is printed on a plane surface. However, the surface of human body is not exactly flat. To Estimate the surface concavity and convexity while measuring the distortion of observed two-dimensional markers is one of our future works. This research was supported in part by the National Institute of Information and Communications Technology.

5. References

[1] KOGURE, K., et al., Toward ubiquitous intelligent robotics, Proc. IEEE/RSJ IROS2003, pp.1826-1831, 2003.

[2] JAIN, A., et al., Biometrics: A Grand Challenge, Proc. IAPR ICPR2004. Vol. 2, pp. 935-942, 2004.

[3] SUMI,Y., et al., Collaborative capturing and interpretation of interactions, Pervasive 2004 Workshop on Memory and Sharing of Experiences, pp.1-7, 2004.

[4] STANFORD, V., Pervasive Computing Goes the Last 100 Feet with RFID Systems, IEEE Pervasive Computing. Vol. 2, No. 2, pp.9-14, 2003.

[5] MURASE, H., et al., Visual learning and recognition of 3-D objects from appearance, International Journal of Computer Vision. Vol. 14, pp.5-24, 1995.

[6] JAIN, A., et al., Recent Advances in Fingerprint Verification, Proc. AVBPA 2001, pp.182-191, 2001.

[7] http://www.denso-wave.com/qrcode/index-e.html

[8] KATO. H., et al., Virtual Object Manipulation on a Table-Top AR Environment, Proc. IEEE/ACM ISAR2000, pp.111-119, 2000.

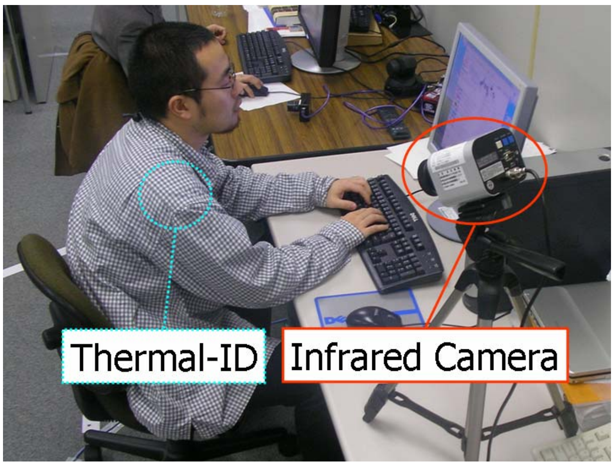

Fig. 4. Scene of Thermal-ID System in Use

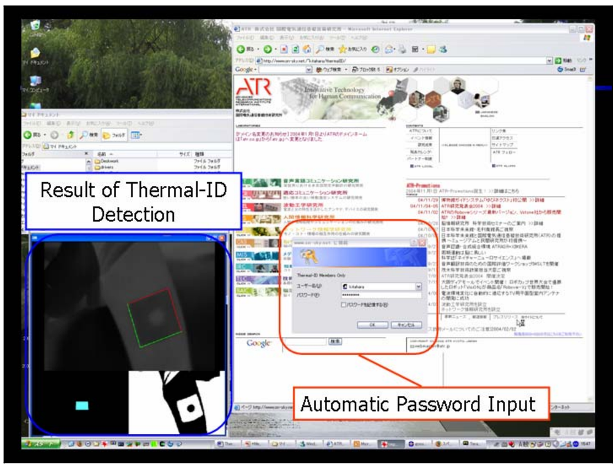

Fig. 5. Screenshot of the function expanded WEB browser