A new anti-theft system based on the recognition of human blood vessels and blood flow

Tie Qiao*, Wan-Chao Huang, Xiao-Bing Luo, Pei-Ming Zheng

Abstract This paper introduces a new type of anti-theft system that combines color Doppler ultrasonography and infrared thermal scanning technology. It can identify the superficial vascular network distribution of a user's palm and dynamic information on blood flow that includes blood flow velocity and pressure, and compares this information with the user's default information to achieve anti-theft capability. The new anti-theft system is designed on the basis of the variation in unique information on the human body, and further increases the safety of present security systems. A Chinese Invention Patent (No. 201110351016.3) on this system has been applied for.

Key words Color Doppler ultrasound; Infrared thermal scanning; Anti-theft system; security.

1 Introduction

With the increasing attention to safety and property, many types of anti-theft systems have been developed. Generally, anti-theft systems are mechanical or electronic depending on the technology used. Mechanical anti-theft systems rely on a mechanical structure matched to a special key. Electronic anti-theft systems rely on complex electronic circuits that combine the use of keys, passwords, sounds and images. Currently, pupil image recognition systems are an advanced form of anti-theft systems. Because the pupil is unique and difficult to replicate, the application of pupil images for identification is a secure approach. Similarly, a fingerprint identification system is another advanced approach based on the unique fingerprints of users [1].

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The anti-theft identification systems have been progressively adopted with the development of technology. The system designs tend to use multiple features to ensure a higher safety factor. For example, a face recognition anti-theft system is designed and modeled according to three factors: illumination, facial expression and gesture to achieve a secure identification [2, 3].

As is well known, the distribution of blood vessels and blood flow velocity in the same part of the body vary between people. In other words, they are unique and cannot be copied. On this basis, we designed a new anti-theft system based on the recognition of blood vessels and blood flow.

Infrared radiation covers a specific frequency range of the electromagnetic spectrum. Both theory and experiment have shown that generally infrared rays exist in nature. Providing the temperature of the emitting object is above absolute zero, it will constantly radiate infrared rays. In other words, every object with 'heat' radiates infrared rays at all times [3]. However, it does not always radiate light, so the infrared ray is also known as the 'heat radiation ray'.

The infrared thermal scanning technique, in which images are captured from the infrared radiation of the observed

objects, was first used in the military field, and the scanning observational accuracy has reached 0.05 ℃ [4]. In clinical medicine, infrared thermal imager can accurately detect the temperature of the body and even display a precise and clear image of the superficial blood vessels of the human body. In addition, an infrared thermal scanning device is used to collect infrared rays and analyze the differences between the infrared wavelengths to diagnose disease.

The Doppler Effect was first proposed by Austrian physicist and mathematician Christian, John Doppler in 1842: the perceived wavelength radiated by an object changes because of the relative motion between the light source and the observer. When the motion is produced in front of the wave source, the wavelength becomes shorter and the frequency increases (blue shift) because the wave is compressed. In contrast, when the motion is produced behind the wave source, it has the opposite effect, the wavelength becomes longer and the frequency becomes lower (red shift). The higher the speed of the wave source, the greater the effect will be. The moving speed of the wave source toward the observed direction can be calculated according to the extent of the blue or red shift [2].

The Doppler effect of acoustic waves has been used for medical diagnosis, namely, the color Doppler ultrasound. It uses a combination of high-resolution black-white B-ultrasound and the color Doppler. Color Doppler ultrasound usually involves Doppler signal processing through a similar related technique. The acquired blood flow signal is then color-coded and superimposed in real-time on the two-dimensional image, which is a color Doppler ultrasound blood flow image [5].

In summary, infrared thermal scanning technology can be imaged using infrared rays of different wavelengths radiated from a human body. Even tiny superficial blood vessels will be observable because of the small temperature difference between the blood and the body surface detected using infrared thermal scanning technology. Thus, a vascular network diagram of certain parts of the body surface can be obtained. Human anatomy shows that the distribution of blood vessels varies between people, and surface blood flow is completely different [7]. If the superficial blood vessels and blood flow of each person are identified and preserved as the basis of the discriminatory elements of an anti-theft system, this combination should be very difficult to copy. This is the theoretical basis of the new anti-theft system [8, 9, 10].

2 Modules

The core of the new anti-theft system is composed of an infrared thermal scanning module and a color Doppler ultrasound module, which constitute the collection module for a user's characteristics. Other modules include the panel, input module, data processing module, central module, power source module, data transmission module, storage module, camera and electronic lock [11]. The schematic diagram of the new anti-theft system is shown in Fig. 1.

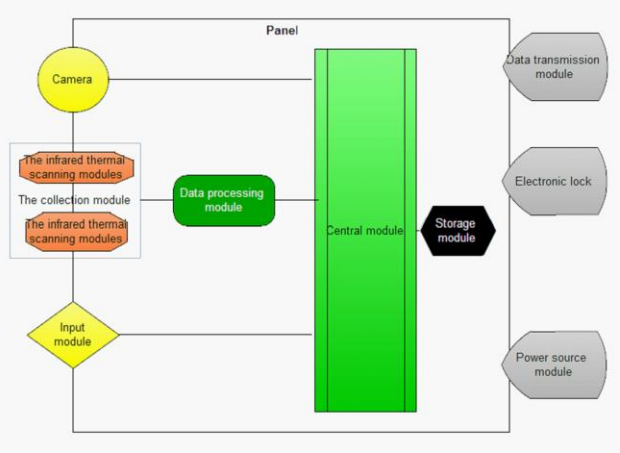

Fig. 1 Schematic diagram of the new anti-theft system

The panel of the new anti-theft system must be made of high-quality alloy materials, which are heat and corrosion resistant to ensure the interior modules work correctly when subjected to a variety of harsh natural environments and user damage [12, 14]. An anti-tamper transducer is fixed on the panel so that it sends out a warning signal when subjected to malicious attacks. At the same time, the electronic lock is activated and a signal transmitted to the security network as an alarm through the data transmission module [13].

The user characteristics are collected by the infrared thermal scanning module and the color Doppler ultrasound module, both of which are installed on the faceplate of the panel and constitute the collection module. The function of this module is to acquire information on the superficial vascular network of the palm and its blood flow. The fundamental structures of the two modules are as follows. The infrared thermal scanning module includes an infrared

optical system array [8] consisting of the infrared sensor array, cooling device and control circuit system. The color Doppler ultrasound module includes the ultrasonic transmitter and receiver. The transmitter emits a specific frequency ultrasonic wave and the receiver receives the reflected waves. The information on the superficial vascular network of the palm and its blood flow is transmitted to a data processing module in data form. These data are finally transmitted to the central module as for verification information after orderly processing. The structural schematic diagram of the collection module is as follows(Fig.2).

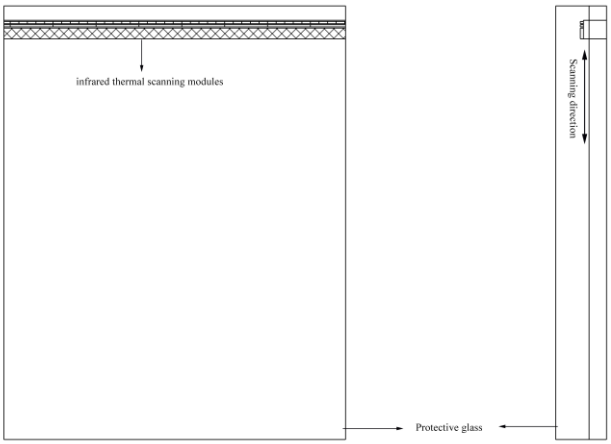

Fig. 2 Collection module

The information collected on the superficial vascular network of the palm and its blood flow is only one part of the verification data. Another is the user's facial features that are captured by a camera. In other words, the image of the user's face is also taken by the camera and transmitted to the central module simultaneously with the information on the palm, as the second verification. The resolution of the camera used was at least 10 million pixels.

In addition to the information and image collected above, users can also input a predetermined code or information through the input module, which can then be transmitted to the central module as the third proof of identity. This input code could be a single or mixed array of numbers and letters.

In the central module , the verification information is compared with the preset data of the target user. If the degree of matching is up to or exceeds 90 %, the user is considered to be correctly identified, and the central module transmits a validation signal to the electronic lock and simultaneously sends the information to the security network through the data transmission module for recording purposes, otherwise, the user cannot be verified by the system. However, the system provides several opportunities to verify again. If the degree of matching is below 90 % through repeated validation, the central module will transmit a locked signal to lock the electronic locks and send information to the security network as an alarm through the data transmission module.

The function of the storage module is to save the default information of the system, such as the superficial vascular distribution of the palm of the target user, the parameters of blood flow velocity, blood pressure parameters, the facial features of the target user and the default password or information.

The data transmission module is the bus connected to the outside security network. All of the system states are transmitted to the security network for backup, or directly as alarms.

The power supply module is connected to an external 220 V alternating current that is converted to a stable current through the conditioning and transformer circuit in the module, so that it provides a safe and reliable energy source for the modules in the system.

The electronic lock starts the switch by receiving the validation signal from the central module and locks the electronic lock by receiving the locked signal. [15,16]

All the above modules are synergistic and work organically and in an orderly manner. The outline drawing of the new anti-theft system is as follows(Fig.3):

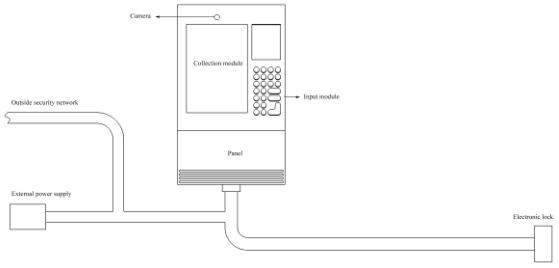

Fig. 3 Outline drawing of the new anti-theft system

3 Method

The working procedure of this new anti-theft system is

as follows. First, install the system correctly, power on and start it. The system needs to output the preset information of one or several users, including: 1. The superficial vascular network distribution of the palm, blood flow velocity and blood pressure collected by placing the palm on the module that collects user features so that the internal infrared thermal scanning module and color Doppler ultrasound module can then carry out top-down scanning of the palm. The ultrasonic emission end of the color Doppler ultrasound module emits the specific frequency of ultrasonic waves automatically, and the ultrasound reflected by the palm is received by the ultrasonic receiver. After this process, the infrared image of the vascular network distribution of the palm surface, blood flow velocity and blood pressure are acquired and stored in the storage module. 2. A standard image of the user's face that is captured and stored by the high-resolution camera. 3. The preset password or information that is input by the input module.

If a user wants to open the electronic lock of the system after completing the input and storage of the preset information, this information must be input with a goodness of fit reaching or exceeding 90 % of the preset information. The procedure is as follows: First, the user places the palm on the collection module to create the infrared image of the vascular network distribution of the palm surface, and the information on blood flow velocity and blood pressure. These data are then transmitted to the processing module and compared with the preset information in the storage module (Fig. 4).

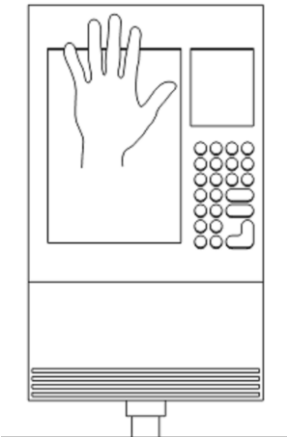

Fig. 4 Schematic diagram for accessing the infrared image of the superrficial vascular network distribution of the palm, and theinformation on blood flow velocity and blood pressure of the user.

At the same time, the facial features of the user are taken by the camera on the panel and a high-resolution picture is transmitted to the central module for comparison (Fig. 5). The user is then asked to input a password or information for verification. If the goodness of fit for the above three conditions reaches or exceeds 90 %, the user is considered to be correctly identified. Meanwhile, the system outputs the user's information to the security network for backup and sends a validation signal to open the electronic lock. Otherwise, the central module will transmit a signal to lock the electronic locks and send an alarm signal to the security network.

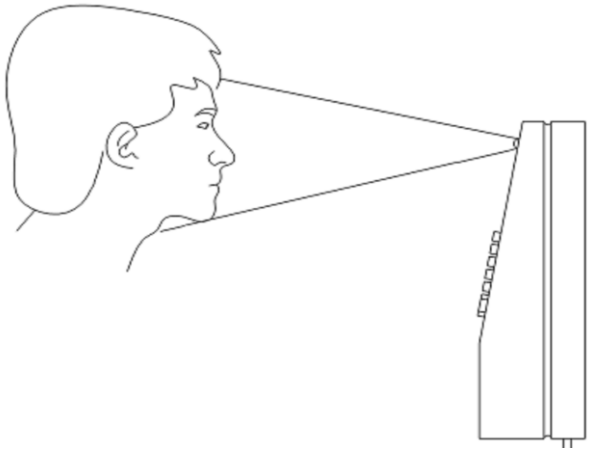

Fig. 5 Schematic diagram for accessing the facial features of the user by the camera

Conclusion

The new type of anti-theft system based on the recognition of blood vessels and blood flow has been submitted for China invention patent (No. 201110351016.3). The design of this device is based on the principles that infrared radiation can be produced from the human body and the intravascular blood flow can produce an ultrasound Doppler effect. Because the vascular network distribution of the palm and the state of blood flow differ between individuals, these characteristics are unique and difficult to duplicate; hence, the compound image of the blood vessels and blood flow is one of the most reliable references for an

anti-theft system. The core method of the anti-theft system described in this article is strongly compatible with other types of security systems. Therefore, it is a convenient method to upgrade existing security systems.

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