Case Study: Influenza Pandemic Countermeasures Utilizing Infrared Thermography

OHTA Jiro

Abstract

As a result of the SARS epidemic of 2003, infrared thermography systems are now in use at airports, seaports and harbors all over the world as a means to quickly detect persons who are displaying symptoms of fever. In 2009, the H1N1 influenza that occurred initially in Mexico, exerted a key influence on developments and private companies as well as airport operators are all showing a keen interest in infrared thermography systems. However, there still remain some issues in the use of infrared thermography systems for fever detection (e.g. body surface temperatures are easily influenced by ambient temperatures and the system thereby tends to yield inconsistent results). This paper discusses the developmental trends of infrared thermography products and describes efforts aimed at improvements in their utilization technologies for further increasing the accuracy of detecting persons exhibiting fever symptoms.

Keywords

infrared thermography, infrared camera, countermeasures for influenza pandemics
detection of fever victims, monitoring of body surface temperatures

1. Introduction

The history of infrared radiation can be traced back to around 1800 when William Herschel (1738 - 1822) found that there is radiation having large thermal effects at wavelengths longer than those of the red region of the sun's visual spectral lines. Since then, considerable numbers of researchers have studied infrared radiation and the technologies obtained by these studies are at present utilized over a wide range of solutions.

In 1971 NEC Avio released an infrared thermography device that incorporated a quantum type sensor (HgCdTe, InSb). At the time, scanning was carried out using a mechanical system employing a galvanometer and a polygonal mirror; it was therefore impossible then to perform scanning as quickly as can be achieved today. At that time more than one minute was required to produce a single image. In addition, it was very difficult to make the sensor compact, and the price was rather high. As a result, the market penetration of infrared thermography rather fell behind. However, in the years around 2000, there was a movement toward improvements via MEMS (Micro Electro Mechanical Systems) and sensor technologies and infrared sensors incorporating UFPA (Uncooled Focal Plane Array) that eliminate the necessity of cooling units then became the mainstream choice. These improvements have resulted in power saving and in size and weight reductions of infrared thermography devices.

At present, infrared thermography is principally used for temperature evaluation in the electrical and electronic fields and for the maintenance of electrical and industrial installations. Moreover, there is currently a fresh demand for the technology. A lot of airport operators and associated enterprises are showing interest in infrared thermography systems as a means of preventing the spread of new influenza viruses at border checkpoints. This paper introduces the developmental trends of new products and discusses the efforts that are being made to utilize improved technologies in order to further increase the accuracy of detection of persons showing symptoms of fever.

2. Differences between a Digital Camera and an Infrared Camera

We usually take action after observing objects and space by our eyes. The wavelength region captured by our eyes is approximately between 0.4 μm and 0.75 μm, and this region is called the "visible light range." Like the human eyes, ordinary digital cameras are designed to be sensitive only to the visible light range. In the visible light range, invisible radiation emitted from the sun and other sources strikes objects and the reflected light captured by our eyes is recognized by humans as familiar shapes. The colors of such objects are determined by the ratios of their reflections. On the other hand, infrared radiation is defined as having longer wavelengths of (0.75 µm - 1,000 µm) than the red region of visible light. Infrared cameras utilize the wavelengths in the ranges having high atmospheric transmissivity (i.e. near infrared rays: 0.8 - 3 µm, middle infrared rays: 3 - 5 µm and far infrared rays: 8 - 13 µm).

In general, cameras utilizing the wavelength ranges of near infrared radiation are called “near infrared cameras” or “night vision cameras.” On the other hand, cameras utilizing the wavelength ranges of the middle infrared radiation and the far infrared radiation are simply called “infrared cameras.” Just as an ordinary digital camera captures reflected visible light, a near infrared camera also captures reflected light and visualizes the reflecting objects. On the other hand, an infrared camera captures the infrared radiation from objects and visualizes them. Objects emit electromagnetic radiation and the energy amount is determined by the degree of the molecular vibration resulting from the infrared radiation energy. Infrared cameras visualize the infrared energy radiated from objects as a distribution of brightness. In addition, the infrared radiation energy has a close relationship with the surface temperature of a radiation source. An infrared camera that can convert infrared radiation energy into temperature and produce images is called an “infrared thermographic camera” or a thermal imager. **Fig. 1** shows the electromagnetic spectrum and the corresponding product configurations.

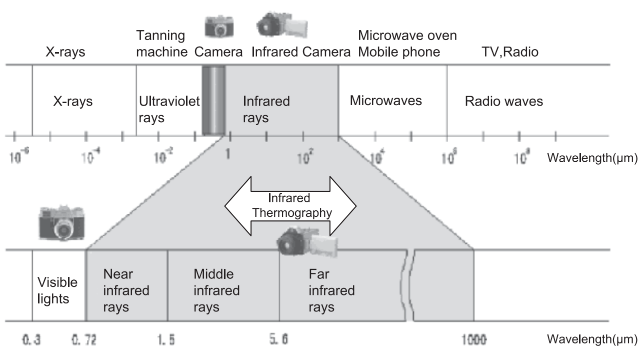

Fig. 1 Electromagnetic spectrum and corresponding product configuration.

3. Approaches to Product Commercialization

In order to use infrared thermography to detect a person who has influenza and high fever, it is essential to understand the relationship between ambient temperature and body surface temperature. NEC Avio has researched the relationship between ambient temperatures and human body surface temperatures by employing thermostatic chambers, and has successfully estimated the body surface temperatures of persons having body temperatures of 38°C or higher. We would like to introduce our approaches to the commercialization of infrared thermography products from the standpoint of preventing outbreaks of influenza.

Aiming at the Improvement of Utilization Technologies

In using infrared thermography for the measurement of body temperature, it is necessary to understand the relationship between body temperature and body surface temperature. NEC Avio has carried out feasibility studies on the differences between body temperatures and body surface temperatures by obtaining the cooperation of employees in order to understand the relationships between such temperature differences. For the feasibility studies, the temperatures of thermostatic chambers were set at 0°C, 5°C, 10°C, 15°C and 30°C, and the habituation period (i.e. time required by the samples to adjust to changes in temperature) was set at 15 minutes. The temperature distributions on faces were measured using infrared thermography, and body temperatures were measured using commercially available contact-type thermometers. In order to obtain average temperatures we then focused on the maximum temperatures among the sample temperature distributions that were captured by infrared thermography. **Fig. 2** shows the graph of temperature distributions of the faces of the test sample immediately after coming out of the thermostatic chambers. The graph shows plots of average body temperatures and body surface temperatures of samples from each of the thermostatic chambers. Regarding the body temperatures, there were no notable changes in the difference of ambient temperatures, because the sample adopted countermeasures to deal with the cold (e.g. wearing more clothes). However, the body surface temperatures changed according to the ambient temperature. It became evident that as the ambient temperature became higher, the body surface temperature came closer to the body temperature. In addition, measurements of the temperatures of oral and ear cavities showed values closer to

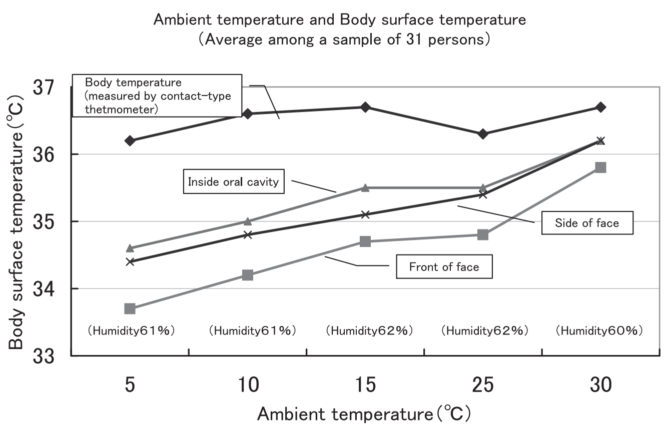

Fig. 2 Difference between body temperature and body surface temperature.

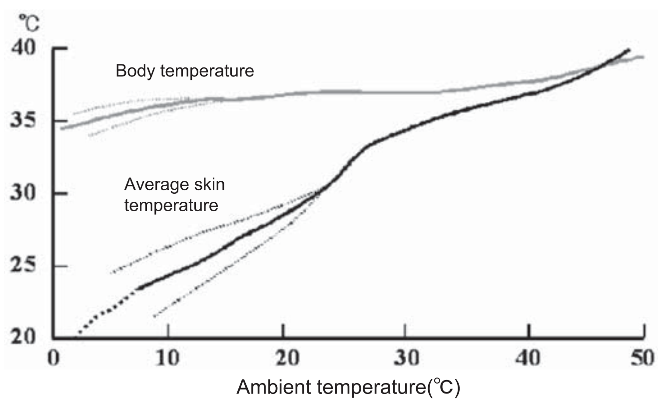

Fig. 3 Difference between body surface temperature and internal body temperature[3].

the body temperatures.

Fig. 3 shows the relationship between body temperatures and body surface temperatures (excerpts from medical literature).

According to Fig. 2, the body temperature was 36.4°C at an ambient temperature of 25°C. The measurement conditions of the data in Fig. 2 and Fig. 3 differ; therefore, there are slight differences in body surface temperature. However, it is evident that as the ambient temperature becomes higher the difference between body surface temperature and body temperature becomes less. These graphs indicate that at airports and other places where the ambient temperatures are relatively stable at around 20°C to 25°C the alarm should be set at approximately 1.6°C lower than the body temperature in order to provide effective detection. For example, when detecting persons whose body temperatures are 38°C or higher, the alarm should be set at 36.4°C. However, Fig. 2 indicates that the difference between the body and body surface temperatures becomes large and the differences among samples are large when the ambient temperature is lower than 15°C. Therefore, it is necessary to make further careful examinations when measuring the body temperatures of persons coming from outside in the winter. According to the results of the measurements of temperature distributions on faces, it is evident that the body surface temperature varies significantly according to the ambient temperature and individual factors. Therefore, when infrared thermography is used, it is necessary to operate it by taking ambient temperature, habituation period and shooting condition, etc. into consideration.

4. Trends in Infrared Thermography Products

Infrared thermography is principally used for industrial purposes, and industrial systems are designed to measure a wide range of temperatures from a low of (-40°C) to a high of (2, 000°C). On the other hand, compared to the industrial system, the infrared thermography system used for the measurement of human body surface temperature is designed to have a much narrower measurement range (0 - 50°C) and a higher measurement accuracy (improved to ±1°C from the conventional ±2°C) in order to realize highly accurate measurements of body surface temperatures. In addition, the system has been altered to convert color images into black and white images and to highlight only the abnormal parts with red color so that it is possible to easily differentiate the images capturing abnormalities from ordinary color images. Since 2009 when the H1N1 influenza occurred, demands for an inexpensive infrared thermography system as a countermeasure for influenza have greatly increased in the private sector. In order to respond to the demand, NEC Avio has developed and released the F30IS for the measurement of body surface temperatures. F30IS is a modified version of the conventional F30 which is an infrared thermography imager designed for industrial use. In the following, we would like to introduce the infrared thermography system that is specially designed as a countermeasure for influenza outbreaks.

4.1 Model Used at a Reception Desk

Photo 1 shows the model designed to be used at a

Photo 1 Model used at a reception desk.

reception desk. The model employs the QQVGA (Quarter-Quarter-VGA) format.

The reception desk model is a camera system designed to detect a person having fever. When a visitor is detected, it starts a recorded voice guidance instruction to move to the front of the camera, and then starts reading the temperature distribution on his/her face. When the measured temperature is above the temperature threshold that has been set for the camera system in advance, it starts voice guidance to the visitor to check his/her temperature using a thermometer. After the temperature has been checked, the visitor consults with a person in the department of General Affairs and decides whether to go into the building or to go home.

4.2 G100IS – Model Used for Onboard Quarantine

NEC is currently examining the idea of releasing the model G100IS infrared thermography imager that boasts high functionality and a high picture quality to be used in onboard quarantine. In order to capture images of persons with a high degree of accuracy, the measurement range is set at from -20°C to 60°C, and the measurement accuracy has been enhanced to ±1°C. The response of G100IS is quick and it achieves a frame time of 60 frames/sec. In addition, it is designed to feature excellent mobility and to achieve a battery life of 4 hours.

Photo 2 G100IS.

Moreover, it is designed to have excellent usability (e.g. employment of a function in which the threshold alarm level is determined based on the results of feasibility studies). **Photo 2** shows G100IS.

5. Operation

Airport operators have established their own precise rules that are operated widely in applying countermeasures on detecting abnormal body temperatures using infrared thermography. However, in the private sector, the environmental conditions for applying countermeasures in an influenza pandemic are different from those required of airport operators. Therefore, some private sectors consult with us as to the requisite countermeasure. In such a case, we at NEC Avio usually advise them to introduce a common camera system that uses infrared thermography. This system is illustrated in **Fig. 4** . As shown in Fig. 4, a visitor is expected to carry out his/her body surface temperature check and to wash his/her hands. In case a re-check of the body temperature is necessary, a visitor should check his/her temperature with a thermometer. However, some visitors visit companies for important matters and have to enter the building. In such a case and in order to minimize any danger caused by such visits, companies should prepare countermeasures to accommodate such visitors, such as by reserving special rooms for them after making sure that they wash and sterilize their hands and wear masks.

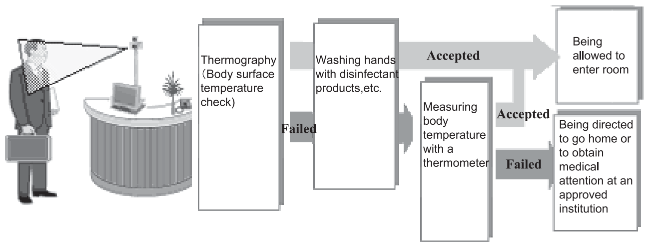

Fig. 4 Operation method of an infrared thermography system.

6. Conclusion

Infrared thermography systems are used at airports all over the world. The reason for this is that all persons to be inspected are subject to the same environmental conditions; therefore, it is relatively easy to detect persons having a high fever. However, the situation is different for that of private sector enterprises that have become interested in infrared thermography systems from the standpoint of their BCPs (Business Continuity Plans) since the H1N1 influenza pandemic occurred in 2009. Such enterprises consider that a fine tuning of alarm settings is required in order to respond to changes in outdoor environmental conditions. Based on our feasibility studies, NEC Avio would like to have more active exchanges of views with researchers and to make every effort to develop new products and further improve relevant utilization technologies. Such a strategy is intended to more effectively contribute to the increasing needs of society.

References

1) J. Ohta and E. Hamada: "Detection of Body Surface Temperature by Infrared Thermography for Prevention of Influenza Pandemic," NEC Technical Journal, Vol.62, No.3, pp.88-92 (2009)

2) J. Ohta: "The Current Status and Future of Thermography," Thermophysical Properties, Vol.25, pp.131-133 (2004)

3) Aschoff J: Hauttemperatur und Hautdurchblutung im Dienst derTemperaturregulation KlinischeWocheuochrift36:193-201, 1958

Author's Profile

OHTA Jiro
Expert
Marketing Division
NEC Avio Infrared Technologies Co., Ltd.