Compensation Method of Infrared Body Temperature Measurement Accuracy Under Mobile Monitoring Technology

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Abstract. Infrared human body temperature measurement is widely used in medicine because of its high safety and flexibility. But in the process of application, there is a big error with the actual temperature. Identify the environmental characteristics of infrared temperature field, judge the high and low temperature area, construct the nonuniformity correction model, convert the electrical signal to the temperature value of the target object, optimize the human body temperature measurement process, introduce the concept of brightness temperature, and use the moving monitoring technology to design the precision compensation mode. The experimental results show that the error mean of the infrared human body temperature compensation method and the other three methods is smaller, which shows that the performance of the method is better.

Keywords: Mobile monitoring technology · Temperature field · Non-contact temperature measurement · Contact temperature measurement · Environmental radiation · Precision compensation

1 Introduction

In the past hundred years, with the progress of human society, human beings have higher requirements for the accuracy, range, sensitivity, real-time and convenience of temperature measurement. The infrared radiation of the detection target is transferred to the infrared detector through the optical imaging objective lens of the infrared thermal imager, and the distribution of the infrared radiation energy is displayed by amplification, shaping and digital mode conversion. Scientists have developed thermocouples, infrared thermometers and infrared thermal imagers and other temperature measuring tools are becoming increasingly mature technology, these tools are not yet perfect because of their limitations. The image produced by the infrared thermal imager reflects the heat distribution of the object surface, and can show the temperature value of each point. It is a very difficult task to use these tools to measure the temperature of the target

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objects in high temperature, high risk and other harsh environments. As a non-contact thermometer, infrared thermometer has been widely used, such as infrared thermometer in public places such as airports and railway stations, etc. [1, 2]. In many applications, there is an urgent need for a high precision, large dynamic range thermometer to achieve reconnaissance, navigation, fire control, NDT and other important applications. Along with people's demand for production and life, more and more applications began to use non-contact temperature measurement technology. Especially in recent years, with the rapid development of infrared focal plane technology and embedded processing technology, the intelligent degree of infrared temperature measurement technology is getting higher and higher. Non-contact temperature measurement uses the detector to detect the radiant energy of the object to achieve temperature measurement. The non-contact temperature measurement method has no limitation of temperature range and can be applied to both medium and low temperature, high temperature and ultra-high temperature. With the development of uncooled focal plane refrigeration technology, the cost of infrared thermal imaging instrument is getting lower and lower, which lays a foundation for the wide application of infrared temperature measurement technology. According to different principles, non-contact temperature measurement methods can be divided into acoustic temperature measurement, spectral analysis, laser interference temperature measurement and radiation temperature measurement. Infrared point thermometer is the earliest infrared thermometer, but its measuring range is too narrow to show the outline of the object. Therefore, the accuracy of the application is very limited. Therefore, the compensation of infrared human body temperature measurement accuracy is deeply studied. Identify the environmental characteristics of the infrared temperature field, judge the high and low temperature areas, build a non-uniformity correction model, convert the electrical signal into the temperature value of the target object, optimize the human body temperature measurement process, and design a precision compensation mode using mobile monitoring technology. The results show that the mean error of temperature measurement data is smaller and the performance is better.

2 Compensation Method for Infrared Human Body Temperature Measurement Accuracy Under Mobile Monitoring Technology

2.1 Identify Environmental Characteristics of Infrared Temperature Field

The electrons, atoms and molecules inside matter are in constant motion, and energy is released in the process of downward transition in the form of electromagnetic waves. Radiation is energy emitted from the interior of matter. The measurement system of infrared temperature field is mainly composed of infrared optical lens, infrared thermal imager, image acquisition equipment and data processing software. When the temperature of the object is higher than the thermodynamic temperature of 0 K, it will continuously radiate electromagnetic waves to the surroundings. Different temperatures of the object will radiate different energy and different wavelengths of electromagnetic waves. Infrared optical lenses are used to focus the infrared energy radiated by the infrared scene to be measured on the photosensitive surface of the infrared detector for imaging. Usually called infrared radiation or infrared, infrared is also a kind of electromagnetic wave, its wavelength range from 0.78 μm to 1000 μm. In the actual radiation model, in addition to its own radiation, an object will reflect and transmit radiation from the environment. Therefore, the energy that reaches infrared optics is mainly composed of three parts, namely:

$$G = \frac{G_1 + G_2 + G_3}{2} \tag{1}$$

In formula (1), G_1 represents the radiant energy of the environment reflected by the target surface, G_2 represents the radiant energy of the target's own surface, and G_3 represents the radiant energy of the environment transmitted from the target surface. If the target emissivity is e, the reflectivity is l, the transmittance is δ, the ambient radiant energy is η (related to ambient temperature), and the radiant energy of the blackbody at the same temperature as the target surface is R, then the formula (2) can be written as follows:

$$H = \sum (el + \delta\eta)^2 - \frac{\delta}{R} \tag{2}$$

The infrared thermal imaging system can convert the received infrared radiation energy into the gray-scale image that can be displayed on the image display device for human eyes to watch. The gray-scale value of the image target corresponds to the radiation energy value of the target point. We can visually judge the regions with high temperature and the regions with low temperature, and can also judge the temperature change of the target by video, but the temperature is the radiation temperature of the target surface, not the real temperature. The infrared thermal imager converts the infrared image light signal of the object to be observed gathered by infrared lens into electrical signal and outputs it after image processing. Temperature determines the thermal radiation characteristics of objects, so radiation can be called temperature radiation. The temperature radiation characteristics of objects are the basis of optical temperature sensing and photoelectric sensing. At room temperature, the object is mainly infrared radiation, the human eye is invisible. The image acquisition device is used to collect and store the image output by the infrared thermal imager for subsequent processing and analysis. This topic uses the standard equipment to carry on the collection. Only when the temperature is raised to about 500 °C will some dark red visible light be emitted. The temperature continues to rise and white light emits. The intensity of thermal radiation is mainly determined by the temperature of the object, the higher the temperature, the stronger the radiation energy, the more infrared radiation. Temperature measurement data processing software is used to process the infrared image collected by the image acquisition equipment, and convert the image data into temperature data for analysis. Infrared radiation, like electromagnetic wave, will be absorbed and reflected in the process of propagation. An object absorbs infrared radiation and converts it into heat energy. As the distance it travels increases, infrared radiation decays. The accuracy of infrared temperature measurement is related to many factors, such as emissivity of object, ambient radiation, tube radiation, nonuniformity of response, gray drift, calibration and data processing algorithm, lens nonuniformity, and distance from target, etc. Because the object at a thermodynamic temperature higher than 0 K, can always spontaneously continue to emit infrared to the surrounding space, so any object under certain conditions can be regarded as infrared radiation source. Blackbody is an ideal source of infrared radiation, which absorbs all electromagnetic radiation at any wavelength. Emissivity is a function of wavelength, temperature, material and radiant surface conditions. It is very difficult to obtain reliable data. The emissivity of the metal is low, but it increases with temperature and can increase tenfold or more when the oxide layer is formed on the surface. The absorbed radiant energy is equal to the emitted radiant energy, which is the biggest characteristic of blackbody. Its absorptivity and emissivity are defined as 1. The temperature value L corresponding to the target with the same radiant energy shall correspond to the radiant energy received by the detector as follows:

$$Q = \frac{(1-\eta)}{\sum |L-e|} \tag{3}$$

In addition, as a result of careless operation caused by fingerprints, dust, dirt and surface scratches, etc., can cause emissivity measurement changes. The emissivity of nonmetals is higher, generally greater than 0.8, and decreases with increasing temperature. Radiation from metals or other opaque materials occurs within a few microns of the surface, so the emissivity is a function of the surface state of the material, independent of size. The gray body as an absorber is not able to absorb all the radiation incident on it, the emissivity is a constant less than 1. Infrared radiation in addition to some of the properties of visible light, but also follow some of the inherent special laws. The emissivity of a coated or painted surface is a property of the coating itself, not of the substrate surface. For the same material, the emissivity may vary from one technical manual to another. The difference is caused by the change of the surface condition of the sample.

2.2 Establishment of a Nonuniformity Correction Model

Inhomogeneity has two definitions, one is the inhomogeneity of infrared detector, the other is the inhomogeneity of infrared imaging, including the inhomogeneity of optical system. The inhomogeneity of infrared imaging refers to the inconsistency of output between different pixels when the input radiation of infrared imaging is uniform. It is well known that the basic theory of infrared thermometry is the principle of infrared radiation and the signal reception and conversion of related electronic devices [3, 4]. Nowadays, infrared thermometer system appears frequently in our daily life. Infrared thermometer is generally composed of optical focusing device, photoelectric detector, operational amplifier, filter circuit, microprocessor and display module. The nonuniformity of infrared imaging system will seriously affect the quality of infrared image, and the accuracy of temperature measurement will be affected. There are many reasons for the nonuniformity of IR imaging response, including inhomogeneity of IR focal plane itself, inhomogeneity of external input and inhomogeneity of working state. The function of the optical focusing device is to gather the infrared radiation energy of the object. The focusing ability is determined by the optical element of the temperature measuring system and its position. When infrared light is focused on a photoelectric sensor through an optical system, the photoelectric sensor converts the light signal into an electrical signal, usually a voltage or inductance signal, that an ADC converter can collect. Ideally, the output signal of the focal plane of the infrared detector should be exactly the same under the uniform infrared radiation. But because of the unevenness of semiconductor material, mask error, defect, technology and other factors, the output of IR detector will appear unevenness, which is the inherent characteristics of infrared detector. The inhomogeneity of the device itself is mainly caused by three aspects: the inhomogeneity of pixel response rate, the inhomogeneity of signal transmission and the inhomogeneity of dark current. In order to obtain the correction parameters, adjust the blackbody temperature to p (low temperature), collect the output q of the infrared focal plane array, and calculate the average value of the whole image as U:

In order to obtain the correction parameters, adjust the blackbody temperature to (low temperature), collect the output of the infrared focal plane array, and calculate the average value of the whole image as follows:

$$U = \frac{1}{p \times q} \sum \frac{p^2}{|q - p|} \tag{4}$$

According to the calculation result of the formula (4), the electric signal can be converted into the temperature value of the target object through amplification, filtering and the internal algorithm of signal processing to achieve the purpose of temperature measurement. In addition, the natural conditions such as ambient temperature, background disturbances and atmospheric conditions should also be taken into account. The emissivity of an object greatly affects the accuracy of the measurement. The inhomogeneity introduced by external input includes: the inhomogeneity of the output of infrared imaging system caused by the change of ambient temperature, external interference, radiation change of optical system and shell. The output signal of focal plane array of infrared detector is closely related to its working state. The change of working state will directly affect the injection efficiency of detector, the gain of readout circuit and dark current, and thus affect the uniformity of the whole infrared imaging system. Emissivity is a key physical parameter for highlighting the surface radiation characteristics of materials. Its value is related to many factors, such as surface temperature, wavelength, incident angle, polarization direction, etc. This close relationship is also affected by surface conditions, including roughness, coating thickness, surface color and physical impurities and other factors. The response curve of the detector is divided into two intervals. Each interval is corrected by the two-point correction method. The correction formula is as follows:

$$T = \frac{q}{\varphi} + E_p + \sum \frac{1}{D} \tag{5}$$

In formula (5), φ represents the gain parameter, E represents the offset parameter and D represents the correction temperature range. It is difficult to achieve the same transmittance in the whole field of view of the lens. Generally, the intermediate transmittance is higher than the edge transmittance. The nonuniformity is mainly shown as multiplication. Because there are many factors affecting the emission frequency, it is not easy to obtain the exact emission frequency of an object. The emissivity of the blackbody radiation source used in the daily calibration work can be said to be the biggest uncertain factor that affects the accuracy of infrared thermometer temperature measurement. Due to the existence of the factors affecting the nonuniformity, the image is characterized by fixed space noise and crosstalk, which seriously affects the quality of the image. Therefore, in order to obtain high quality images and ensure the accuracy of temperature measurement, the nonuniformity of infrared imaging response must be corrected.

2.3 Optimize Human Body Temperature Measurement Process

When we use infrared thermometer to measure human body temperature, the measured object is human skin, but most of the skin is often wrapped by clothes, only the head is exposed, so the measured part is selected for forehead and eardrum. The eardrum is measured because its temperature is similar to the body's internal temperature. But the ear warm gun needs to contact with the human body, the use is not convenient. In the process of temperature measurement, infrared ray is a kind of electromagnetic wave, which is located at the right end of the visible spectrum of light. Forehead temperature is the highest point of the skin temperature of the head, most of the infrared thermometers choose the forehead as the body's temperature measurement target. However, the temperature of the forehead is not equal to the temperature of the human body, the temperature of the two is affected by many factors, the relationship between the two is not constant, so the forehead temperature needs to be corrected. Infrared radiation is a natural phenomenon on all objects, any object above absolute zero temperature is the source of infrared radiation, which mainly includes ultraviolet, visible light, infrared and so on. Therefore, people should be measured in a resting state, so that their body temperature and ambient temperature to achieve a balance. Only when the heat exchange of the object is stable, can the temperature instrument be used to measure the result. The time response is slow, so it is not suitable for monitoring small target and instantaneous temperature. With the development of science and technology, it has been studied to use contact temperature measurement technology and high-speed data acquisition technology in industrial temperature measurement. Non-contact temperature measurement plays an important role in infrared technology because it has many advantages, such as non-contact, high sensitivity, high precision, wide application, simple operation and so on. In addition, the use of infrared detection of human body temperature, people's age, gender will also affect the detection results. Older people and women had the weakest correlation with body temperature compared to other people, with young people having the best correlation. Because of the reason of old people's physical quality, the influence of cold on body temperature is not as obvious as that of young people. Infrared thermometer is firstly applied to measure temperature in clinic. At the initial stage of infrared technology, its promotion is hindered by the application of detector. Infrared detectors can convert infrared radiation emitted by an object to electrical energy, which can be converted to voltage or current or to detect changes in physical properties of materials. The comparison between infrared thermometer and mercury thermometer shows that infrared thermometer can also ensure high accuracy and correlation, and can measure temperature in 2 s, and let children feel comfortable. The main wavelength of radiant energy is functionally related to temperature, surface state and emissivity. Common temperature measurements are shown in Fig. 1:

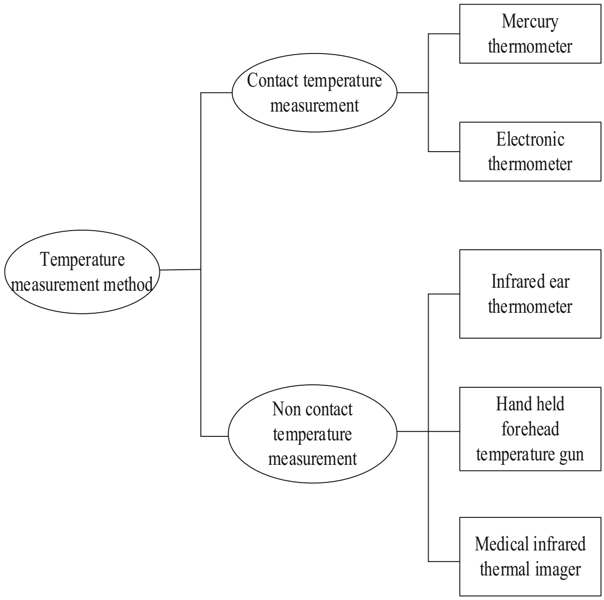

Fig. 1. Diagram of common temperature measurement methods

As can be seen from Fig. 1, the common temperature measurement methods include: contact and non-contact temperature measurement. Among them, contact thermometer includes: mercury thermometer and electronic thermometer. Non-contact thermometers include infrared ear thermometers, hand-held forehead thermometers, and medical infrared thermal imagers. A large number of field and clinical trials show that there are obvious differences between human body surface temperature and internal body temperature. The skin temperature varies according to ambient temperature, physiology, and movement. Only know the skin temperature is unable to determine the real temperature of the human body. The skin temperature is determined by the internal temperature of the human body and is affected by external factors. The infrared band is divided into many different names according to the electromagnetic wave spectrum. The division method is based on the dissemination method, the production way as well as the use situation different and so on principle divides. The infrared band can be divided into four types, as shown in Fig. 2:

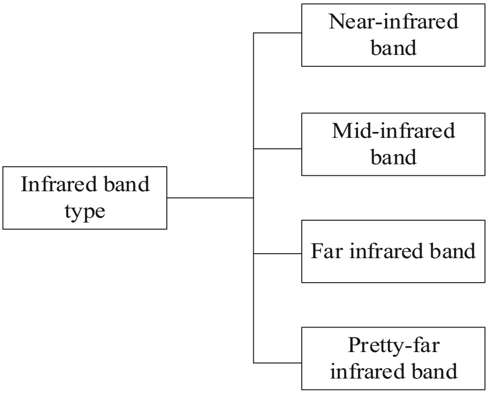

Fig. 2. Infrared band types

As can be seen from Fig. 2, infrared band types include: near infrared, middle infrared, far infrared and far infrared, the specific way of classification may vary according to the subject area. Forehead temperature is determined by brain temperature. Many researchers have established a brain heat transfer model, studied the theory of brain heat transfer, and discussed the effect of heat conduction, convection and metabolism on brain temperature. The conclusion that ambient temperature and convective heat transfer coefficient have a great effect on the temperature of the head surface is obtained by theoretical analysis and practical verification. The skin temperature of the head changed linearly with the environment temperature. The skin temperature of the head increased by 2.06 °C for every 10 °C increase of the environment temperature. The theoretical basis of monochromatic radiation thermometry is Wien's formula. The radiation power of a blackbody is a function of wavelength and temperature, and when the wavelength is fixed it is only related to temperature. When the measurement is received by the measured object in a certain direction of the radiation emittance, called spectral radiation brightness. The monochromatic radiant thermometer is calibrated by the spectral radiance of the blackbody, and it will be deviated if the measured object is not blackbody. The skin temperature was influenced by the ambient temperature in different sites and seasons, which affected the accurate measurement of the forehead temperature. Convective heat transfer coefficient is determined by wind speed, and the change of convective heat transfer can significantly affect the surface temperature of the head. Therefore, when we use infrared thermometer to measure human body temperature, we should choose the place with stable ambient temperature and low wind speed, or modify it according to the different environment. Because the spectral radiance of the blackbody is higher than that of the non-blackbody at the same temperature, the temperature of the non-blackbody measured by the instrument is lower than the true temperature. In order to calibrate the temperature deviation, the concept of brightness temperature is introduced. Generally speaking, there are two types of thermometer: contact and non-contact. The physiological parameters and activities of human body also affect the temperature of brain, such as blood perfusion rate, metabolism rate and skin thermal conductivity coefficient. Among them metabolic rate is bigger to skin temperature effect, metabolic taller, the heat that produces more.

2.4 Design Precision Compensation Mode of Mobile Monitoring Technology

Mobile monitoring technology, through the temperature measurement of the target behavior characteristics of sampling, calculation and description of the target behavior parameters after the formation of precision compensation [5–7]. Compared with the normal behavior model, the results of temperature measurement with large statistical deviation were identified as abnormal. Through statistical analysis or transformation of the data, the normal detection accuracy can be separated from the temperature data and noise. When the target is larger than the field of view of the infrared thermometer and the influence of atmospheric transmittance is negligible, the radiation intensity to the detector is independent of the distance between the object and the system. Generally, thermal imager is used in outdoor environment. Because of the change of atmospheric absorptivity, atmospheric background temperature, ambient temperature and the influence of nearby objects, the influence of thermal imager on infrared instrument is more complex and changeable, so that it affects the difficulty of using infrared instrument to measure temperature accurately in reality. Although filters filter out most of the infrared wavelengths, there are still a lot of infrared wavelengths of objects in the human body and similar to the 9 to 14 μm band. For example, the infrared wavelength of the Earth is 10 μm, so when using infrared thermometer to measure, we should try to reduce the infrared interference of other targets. There is an eyepiece above the infrared sensor, which determines the angle of view of the infrared detector to detect the infrared radiation. To reduce the interference of other objects to detect the target, the measured target should be full of the whole angle of view. However, for the infrared ear thermometer, the target is close to the infrared ear thermometer, and is in the relatively airtight ear canal environment, so the influence of measurement distance on the infrared ear thermometer is almost negligible. If the temperature is only determined according to a certain data of the input emissivity, the accuracy of the temperature measurement will be greatly affected. Moreover, the influence of emissivity is different with different temperature measuring instruments. If the monochromatic thermometer is used, the error of the luminance temperature is:

$$\left(\frac{\sigma}{Y}\right)^{-Y} = \frac{(1)}{\sigma^2} \tag{6}$$

In formula (6), σ represents ambient temperature and Y represents radiant energy error. To sum up, the factors affecting infrared temperature measurement are complex, such as measuring distance, emissivity, ambient temperature and atmospheric factors, etc. The infrared radiation emitted by the temperature target radiates in all directions, and the infrared radiation received by the sensor is only a small part of it. The rest of the energy is released into the surrounding space. But the angle coefficient of the surrounding environment to the lens is very small, so the influence of the environment to the direct thermal radiation of the lens is very small. For infrared ear thermometers, the ear thermometer needs to be inserted into the ear canal, and the thermometer is located in a relatively airtight environment. It can be seen from the analysis that the infrared thermometer has a great influence on the temperature when the distance of the object is more than 5 cm from the receiver, while the distance of the infrared thermometer from the tympanic membrane is small. The corrected value of an infrared ear thermometer is mathematically expressed as follows:

$$\Delta = \psi - k \frac{\psi}{\sum_{x=1} k_{|x-d|}} \tag{7}$$

In formula (7), ψ stands for the temperature of the black body, k stands for the average temperature of the black body measured by the infrared ear temperature system, and d stands for the d temperature reading. The infrared ear thermometer is located in a relatively closed space, and the atmospheric factors have little influence on the measurement results. According to the infrared radiation theory, the target emissivity is always less than 1, and the emissivity of different materials is different, so we need to set the target emissivity before detecting the target. According to the nonblackbody radiation theory, the ratio of the radiant energy of the gray body to that of the black body is the emissivity, so the different emissivity will cause the error of the measurement. The emissivity of human skin is fixed, but for different people, the material and surface roughness of earwax will directly affect the emissivity, which will affect the measurement accuracy of infrared ear thermometer. To sum up, the radiant energy received by the lens mainly depends on the temperature and ambient temperature, the emissivity of the temperature target, the wavelength and area of the temperature lens, the distance between the lens and the target and the alignment of the target. However, a closed space creates a dark environment that can significantly reduce individual differences in emissivity, which can affect measurements, although the impact of emissivity cannot be ignored [8]. And the drift caused by the external environment temperature is compensated. Based on the above analysis, the influence of target emissivity, atmosphere factor and measurement distance on the error of infrared ear thermometer is limited, and the ambient temperature has great influence.

3 Experimental Analysis

3.1 Test Readiness

Prepare the test according to the test requirement. When the human body temperature measurement system began to carry out human body temperature measurement, initialization of infrared temperature sensor MLX90614, ranging sensor VL53L1. When the button is pressed, the MLX90614 infrared temperature sensor begins to collect the forehead temperature and ambient temperature. The driver is selected under the big option Device Drivers, in which, select Samsung S3C2440/S3C2442 Serial port support under Character Devices I > Serial driver to add the serial port driver. Select support for Video for Linux under Multimediadevices, and select USB SPCASXX Sunplus/Vimicro/Sonix Jupeg Cameras to add a driver for the USB camera. VL53L1 rangefinder begins to measure distance. The temperature and distance data collected by the sensor are preprocessed and filtered by MCU controller. When the pretreatment is finished, the forehead temperature is judged. The DSP for the USB camera selected in the experiment is owned by SOnix, so be sure to choose this option. In Graphics support, select Support for frame buffer devices, and select the appropriate branding and size of the LCD screen. If the forehead temperature value is within the normal forehead temperature range (32–36 °C), the human body infrared temperature measurement system calculates the collected data by multiple linear regression algorithm to fit the human body sublingual temperature value, and Linux abstracts FrameBuffe: This device can be used for user mode process to realize direct writing screen. By imitating the function of video card, the Framebuffer mechanism abstracts out the hardware structure of video card, and can directly operate on video memory through the Framebuffer. If the collected forehead temperature is not in the range of normal forehead temperature, the collected data can not be corrected by multivariate regression algorithm, and the forehead temperature can be directly output and buzzer can give an alarm. Users can think of a Framebuffer as an image of display memory that, once mapped into a process address space, can be directly read and written, which can be immediately reflected on the screen.

3.2 Test Results

When the human body is chosen as the object of temperature measurement, the armpit temperature is firstly measured by medical mercury thermometer, and the forehead temperature is measured by DS18B20 before measurement. Because the normal body temperature change is not big, basically in 37 °C, change range in ± 1 °C or so, but not always constant. Therefore, it is necessary to ensure that the temperature measurement environment is indoor without wind and the ambient temperature remains unchanged. The armpit temperature and forehead temperature of human body should be measured before the infrared measurement, and then measured again after the infrared measurement. In order to verify the effectiveness of the compensation method of infrared human body temperature measurement precision designed in this paper, the compensation method of infrared human body temperature measurement precision based on data mining, the compensation method of infrared human body temperature measurement precision based on association rules and the compensation method of infrared human body temperature measurement precision based on genetic algorithm are selected respectively, and the experimental comparison is made with the compensation method of infrared human body temperature measurement precision proposed in this paper. Under different distance conditions, the error of temperature measurement data of four compensation methods is tested respectively. The experimental results are shown in Tables 1, 2, and 3:

Table 1. Error of 5 cm distance temperature data (°C)

Number of experiments	Compensation Method for Infrared Human Body Temperature Measurement Accuracy Based on Data Mining	Compensation Method for Infrared Human Body Temperature Measurement Accuracy Based on Association Rules	Compensation Method for Infrared Human Body Temperature Measurement Accuracy Based on Genetic Algorithm	Compensation Method of Infrared Human Body Temperature Measurement Accuracy
1	0.631	0.552	0.487	0.312
2	0.584	0.547	0.569	0.254
3	0.612	0.569	0.612	0.331
4	0.538	0.499	0.613	0.214
5	0.622	0.523	0.647	0.206
6	0.529	0.511	0.685	0.319
7	0.642	0.602	0.652	0.256
8	0.566	0.542	0.636	0.311
9	0.608	0.536	0.548	0.256
10	0.577	0.629	0.602	0.229

From the Table 1, we can see that the average error of the infrared human body temperature compensation method is 0.269 °C, 0.591 °C, 0.551 °C, 0.605 °C.

Table 2. Distance 20 cm Temperature Data Error (°C)

Number of experiments	Compensation Method for Infrared Human Body Temperature Measurement Accuracy Based on Data Mining	Compensation Method for Infrared Human Body Temperature Measurement Accuracy Based on Association Rules	Compensation Method for Infrared Human Body Temperature Measurement Accuracy Based on Genetic Algorithm	Compensation Method of Infrared Human Body Temperature Measurement Accuracy
1	2.361	2.216	2.364	1.023
2	2.225	3.066	2.358	1.114
3	2.198	2.108	3.169	1.028
4	2.647	3.669	2.087	1.136
5	3.105	2.874	3.647	1.087
6	2.697	3.692	2.848	1.154
7	2.684	2.588	2.154	1.364
8	3.005	3.615	2.199	1.154
9	2.647	2.347	3.647	1.255
10	2.712	2.165	2.088	1.346

From the Table 2, the mean error of the infrared human body temperature compensation method is 1.166 °C, 2.628 °C, 2.834 °C, 2.656 °C.

Table 3. Error of 35 cm temperature data (°C)

Number of experiments	Compensation Method for Infrared Human Body Temperature Measurement Accuracy Based on Data Mining	Compensation Method for Infrared Human Body Temperature Measurement Accuracy Based on Association Rules	Compensation Method for Infrared Human Body Temperature Measurement Accuracy Based on Genetic Algorithm	Compensation Method of Infrared Human Body Temperature Measurement Accuracy
1	5.647	5.648	5.697	2.647
2	5.649	6.021	5.879	3.316
3	5.558	6.213	6.112	2.226
4	5.648	5.879	5.948	2.314
5	6.115	6.337	6.377	3.051
6	6.233	5.874	5.869	3.099
7	6.487	6.599	6.451	2.874
8	6.255	5.788	5.846	2.694
9	6.369	6.347	6.464	3.008
10	5.998	6.124	6.997	3.154

From the Table 3, the mean error of the temperature compensation method and other three methods is 2.838 °C, 5.996 °C, 6.083 °C and 6.164 °C.

To sum up, the infrared human body temperature measurement accuracy compensation method under mobile monitoring technology has low error mean value of temperature measurement data and good performance. The reason is that this method carries out statistical analysis or transformation on the data to separate the normal detection accuracy from the temperature measurement data and noise. When the target is larger than the field of view of the infrared thermometer and the influence of atmospheric transmittance can be almost ignored, the radiation intensity incident on the detector has nothing to do with the distance between the object and the system, which is conducive to reducing the temperature measurement error to a certain extent.

4 Conclusion

A large number of temperature data are measured in the absence of external environment interference, and the precision compensation formula is fitted by moving monitoring technology and least-squares method. The method solves the problem that the traditional infrared body temperature measurement is easily affected by the ambient temperature and measurement distance, and improves the accuracy of infrared body temperature measurement.

Due to the limited time and energy, the samples measured in the temperature measurement experiment only have the measured data values at normal body temperature. For the high fever data with fever, no experimental measurement is carried out. It needs to be further improved in the future. The specific contents are as follows:

(1) In order to better facilitate the service of patients, the size of the data collection node needs to be further reduced, and the shape needs to be designed for different age groups to bring more comfortable experience to patients.
(2) The data in the data acquisition system is finally collected in the coordinator module. In actual use, when the number of data nodes reaches thousands, the coordinator module may not be able to carry such high-intensity data traffic. The method of transmitting data to the PC client through serial port is no longer applicable, and other communication methods need to be used to transmit data to the database.
(3) Although the PC client software can realize the functions of real-time display and query of data, it can not diagnose the measured body temperature. It can be considered to realize the early warning and diagnosis of some common diseases on the basis of the system in combination with the specific application of physiological parameters of body temperature in clinic.

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