27 OCT 2005

METHOD AND APPARATUS FOR MEASURING TEMPERATURE OF A BODY

FIELD OF THE INVENTION

The present invention relates to a method and apparatus for measuring the temperature of a body or object, of particular but by no means exclusive application in the measuring the temperature of a person for the detection of persons displaying symptoms of Severe Acute Respiratory Syndrome (SARS).

BACKGROUND OF THE INVENTION

One existing method of screening people for diseases that induce fever is by means of visual and using clinical thermometer to measure the body temperature of each person. For example, any person with a measured temperature of 38°C and above is considered to be potentially infected with SARS. This is based on the key indicator that a suspected SARS infection will have a onset of high fever. However, such a method of screening requires close contact with the suspected person and is very slow.

More generally, infrared imaging systems have been used for surveillance purposes, preventive maintenance and thermography applications. However such systems are inaccurate, typically having a good resolution (of 0.1°C) but an accuracy of only ±2°C. Hence, such systems cannot be used to accurately measure the temperature of the body.

SUMMARY OF THE INVENTION

The present invention provides, therefore, a method of measuring the temperature of a object, comprising:

creating image data corresponding to an image of said object by means of a infrared camera and representable as a greyscale image of said object;

establishing a temperature calibration for said greyscale image; and

deducing said temperature from said greyscale image and said temperature calibration;

wherein establishing the temperature calibration for the greyscale output comprises collecting calibration data by imaging a substantially monochromatic thermal source by means of said infrared camera and selecting or modifying a predetermined calibration of said greyscale output of said infrared camera on the basis of said calibration data.

Thus, the problem of lack of accurate infrared imaging systems is addressed by calibrating the infrared camera in terms of a greyscale image. It will be understood that the image of the object (such as a person), as in common usage, may comprise an image of a portion of the object (such as the face of a person).

The object could be an animal, plant, inanimate object, person, or any other object.

The predetermined calibration may be suitable for a first set of environmental or usage conditions and the method may include modifying the predetermined calibration to be suitable for a second set of environmental or usage conditions. More preferably modifying the predetermined calibration comprises normalizing the predetermined calibration according to a reference greyscale image of the thermal source.

The thermal source may be provided in the infrared camera.

The thermal source may be one of a plurality of thermal sources.

Preferably the first set of conditions and the second set of conditions are each characterizable in terms of ambient temperature.

Thus, the predetermined calibration may apply only when the ambient temperature is, say, 28°C (constituting in this

example the first set of conditions), but the second set of conditions may comprise an ambient temperature is, say, 32°C.

Alternatively, the sets of conditions may relate to the use of the infrared camera, such as whether it has been just switched on or has been in operation for an extended period.

In one embodiment, the method includes establishing the temperature calibration at a temperature or over a temperature range approximating or corresponding to an expected range of said temperature.

In one embodiment, the method includes establishing the temperature calibration at a temperature or over a temperature range approximating or corresponding to an expected range of said temperature, wherein said reference thermal source has a temperature in or at the limits of said range.

Typically the method may include extrapolating a surface temperature of the object to a core temperature of the object, based on the known relationship between these values.

Preferably said method includes outputting said image in colour coded or greyscale form so that said temperature can be ascertained visually at one or more portions of said object.

In one aspect, the camera is replaced with an infrared detector with a field of view sufficiently narrow that a measure of the temperature of the person (or other object) can be ascertained by the method above. This may be in the form, for example, of a spot thermometer boresighted to a CCD camera.

In another aspect, the invention provides a method of measuring the temperature of a person, comprising:

creating image data corresponding to an image of said person by means of said infrared camera and representable as a greyscale image of said person; and

establishing a temperature calibration for said greyscale image;

deducing said temperature from said greyscale image and said temperature calibration.

The invention also provides an apparatus for measuring the temperature of an object, comprising:

an infrared camera for outputting image data corresponding to or representable as a greyscale image of said object; and

computing means;

wherein said computing means is configured to receive said image data, to establish a temperature calibration for said greyscale image and to deduce said temperature from said greyscale image and said temperature calibration.

Preferably the computing means is operable to establish the temperature calibration for the greyscale image by modifying a predetermined calibration that is suitable for a first set of environmental or usage conditions to be suitable for a second set of environmental or usage conditions. More preferably the computing means is operable to modify the predetermined calibration by employing at least one reference greyscale image of at least one reference thermal source in the second set of conditions and normalizing the predetermined calibration according to the reference greyscale image.

The infrared camera may include the thermal source or sources.

Preferably the apparatus includes a display. More preferably the display is a printer or a video screen or a numerical readout of temperature (either at one or more points of said person or as an average).

BRIEF DESCRIPTION OF THE DRAWING

In order that the present invention may be more clearly ascertained, an embodiment will now be described, by way of example, with reference to the accompanying drawing, in which:

Figure 1 is a schematic view of an apparatus for screening people for SARS infection according to an embodiment of the present invention;

Figure 2 is a schematic view of the apparatus of figure 1 set up for use in screening people for SARS infection;

Figure 3 is a graph of calibration results for the camera of the apparatus of figure 1 performed at different distances between reference thermal source and camera;

Figure 4 is a graph of calibration results for the camera of the apparatus of figure 1 performed at a fixed distance but under varying conditions as a check on repeatability; and

Figure 5 are infrared images collected by means of the apparatus of figure 1.

DETAILED DESCRIPTION

An apparatus screening people for SARS infection according to an embodiment of the present invention is shown schematically in figure 1, generally at 10. The apparatus 10 is a fast, non-intrusive, passive and reliable system for mass screening of people for possible SARS infections. It is essentially a non-contact measurement of human body temperature to detect a person with fever from a remote distance of more than 1 m. The apparatus 10 can be

deployed at airport terminal, causeway check point, seaport check point, hospitals, clinic, schools, convention halls, etc.

The apparatus 10 could also be adapted for similar applications to measure accurately temperatures of animals, plants, inanimate and other objects .

The apparatus 10 includes an accurately calibrated passive infrared camera 12. An image, once obtained by means of the camera 12, is outputted as greyscale image 14 to personal computer 16 where it is processed electronically and then displaying as a false colour picture 18 on video display monitor 20.

Figure 2 is a schematic view of apparatus 10 set up for screening for SARS. It is envisaged that the apparatus 10 would be in portable form for deployment at entrances where there is a constant flow of people. The apparatus 10 is configured to screen both tall and short people (typically adults and children respectively) in real time. The apparatus 10 is preferably automated for use with a motorised gate that opens automatically only when the person is detected to have normal temperature.

As mentioned above, most infrared cameras are not sufficiently accurate. This problem is addressed in this embodiment by calibrating the infrared camera 12 at a temperature within the expected temperature range. The method of calibration is by means of a reference thermal source. The output of the infrared camera in greyscale level is then plotted against the temperature of the thermal source. Figures 3 and 4 are graphs of typical calibrations under various conditions. Figure 3 is a graph of calibration results for the camera 12 performed at different distances between reference thermal source and camera, while figure 4 is a graph of calibration results

for the camera 12 performed at a fixed distance but under varying conditions as a check on repeatability.

From these results, it is apparent that the greyscale level varies linearly with the temperature and can be repeated consistently under the same environmental conditions. Based on this characteristic, the result is stored electronically and used for further computation to provide the false colour of the final picture 18.

It was also found that once the apparatus 10 had been calibrated at the set-up location, the apparatus can be quickly calibrated by using a single temperature setting. This is to correct for any change in the temperature of the environment or temperature sensor. This can be seen in figure 4, where the gradient remains fairly constant.

Based on the relation between the body temperature and the skin temperature, the color temperature of the image can then be set to indicate a person with normal, feverish or fever temperature. The processing is done by the video graphic card in the personal computer 16 before the final picture 18 of the person is displayed on the color monitor 20.

Trials had been performed on more than 100 persons and the photographs of figure 5 show some of the results. A person with fever is readily identified by the red color of his forehead and neck.

The distinct advantages of this apparatus include:
It provides a non contact screening method and hence avoid spreading of the virus

- It is fast and avoids delay, hence does not cause inconvenient to the person under screening;
- It provides a simple and intelligent system, which consequently does not require a skilled operator

- It permits efficient mass screening, hence saving in manpower resources;
- It is reliable and ensure continuous monitoring.

In an alternative embodiment, a spot thermometer boresighted to a CCD camera is used instead of the camera. However, in this case the system is be pointed accurately at, preferably, the forehead of the person to be screened. When the temperature exceeds a certain value, an alarm can be set to indicate that the person has a fever.

Modifications within the scope of the invention may be readily effected by those skilled in the art. It is to be understood, therefore, that this invention is not limited to the particular embodiments described by way of example hereinabove.

Further, any reference herein to prior art is not intended to imply that such prior art forms or formed a part of the common general knowledge.

CLAIMS:

1. A method of measuring the temperature of an object, comprising:

creating image data corresponding to an image of said object by means of an infrared camera and representable as a greyscale image of said image;

establishing a temperature calibration for said greyscale image; and

deducing said temperature from said greyscale image and said temperature calibration;

wherein establishing the temperature calibration for the greyscale output comprises collecting calibration data by imaging a substantially monochromatic thermal source by means of said infrared camera and selecting or modifying a predetermined calibration of said greyscale output of said infrared camera on the basis of said calibration data.

2. A method as claimed in claim 1, wherein said predetermined calibration is suitable for a first set of environmental or usage conditions and the method includes modifying said predetermined calibration to be suitable for a second set of environmental or usage conditions.

3. A method as claimed in claim 2, wherein the modifying of the predetermined calibration comprises normalizing said predetermined calibration according to a reference greyscale image of said thermal source.

4. A method as claimed in claim 2, wherein said first set of conditions and said second set of conditions are each characterizable in terms of ambient temperature.

5. A method as claimed in claim 1, including establishing the temperature calibration at a temperature or over a temperature range approximating or corresponding to an expected range of said temperature.

6. A method as claimed in claim 3, including establishing

the temperature calibration at a temperature or over a temperature range approximating or corresponding to an expected range of said temperature, wherein said reference thermal source has a temperature in or at the limits of said range.

7. A method as claimed in claim 1, including extrapolating a surface temperature of said object to a core temperature of said object, based on a known relationship between said surface temperature and said core temperature.

8. A method as claimed in claim 1, including outputting said greyscale image in colour coded or greyscale form so that said temperature can be ascertained visually at one or more portions of said object.

9. A method as claimed in claim 1, including creating said greyscale output of said infrared camera from non-greyscale data output by said camera.

10. A method of measuring the temperature of a person, comprising:

calibrating an infrared detector at a temperature or over a temperature range approximating or corresponding to an expected range of said temperature;

creating an image of said person by means of said infrared detector; and

deducing said temperature from said image;

wherein said infrared detector has a field of view sufficiently narrow that a measure of the temperature of said person can be ascertained.

11. A method as claimed in claim 10, wherein said infrared detector is in the form of a spot thermometer boresighted to a CCD camera.

12. A method as claimed in claim 1, wherein said object is a person or a part of a person.

13. An apparatus for measuring the temperature of an object, comprising:

an infrared camera for outputting image data corresponding to or representable as a greyscale image of said object; and

computing means operable to receive said image data, to establish a temperature calibration for said greyscale image by selecting or modifying a predetermined calibration of said greyscale output of said infrared camera on the basis of calibration data collected by means of said infrared camera and a substantially monochromatic thermal source, and to deduce said temperature from said greyscale image and said temperature calibration.

14. An apparatus as claimed in claim 13, wherein the predetermined calibration is suitable for a first set of environmental or usage conditions and the computing means is operable to modify said predetermined calibration to be suitable for a second set of environmental or usage conditions.

15. An apparatus as claimed in claim 14, wherein the computing means is operable to modify the predetermined calibration by normalizing said predetermined calibration according to a reference greyscale image of said thermal source.

16. An apparatus as claimed in claim 12, including a display.

17. An apparatus as claimed in claim 16, wherein said display is a printer or a video screen or a numerical readout of temperature.