

TEMPERATURE DISTRIBUTION DETECTING APPARATUS AND METHOD
OF DETECTING A TEMPERATURE DISTRIBUTION

Background

5 [0001] The present invention relates to a temperature distribution detection technique of detecting a temperature distribution in a room on a basis of thermographies obtained by a plurality of infrared sensors.

10 [0002] In the past, there is proposed a technique of automatically controlling a room environment, for example, the technique including detecting thermographies of a room by a plurality of infrared sensors such as thermopile array sensors attached on walls or a ceiling,
15 detecting a person region indicating a person's skin temperature from the obtained thermographies, detecting an in-room person, controlling only a room or an area with the in-room person to be a comfortable air-conditioning environment, and stopping air-conditioning
20 and lighting in a room or an area with no in-room person (for example, see Japanese Patent Application Laid-open No. 2012-057840, etc.).

25 [0003] Further, when measuring a temperature by using a plurality of infrared sensors and if the devices have variations, the temperatures measured by those devices may sometimes not be the same even if the same temperature is measured actually.

30 [0004] To solve the aforementioned problem, in the past, there is proposed a technique of calculating a temperature difference between detected-temperatures of overlapped regions, on which measured regions of adjacent

infrared sensors overlap with each other, and correcting the detected-temperatures of the infrared sensors on a basis of the obtained temperature difference (for example, see Japanese Patent Application Laid-open No. 2014-016223, etc.).

[0005] However, according to the prior art, a temperature difference is calculated on a basis of detected-temperatures detected in overlapped regions of adjacent infrared sensors. However, the two detected-temperatures do not always indicate the temperature of the same object. Therefore, where a temperature difference is calculated from representative detected-temperatures of different targets, it is not possible to correct the detected-temperatures of the infrared sensors accurately, which is a problem.

[0006] For example, an obstacle such as a separation is placed on an overlapped region, and a heat-generating object such as a person is behind a side of the obstacle. In this case, one infrared sensor detects, as a detected-temperature, a temperature not affected by the heat-generating object because the heat-generating object is behind the obstacle. Meanwhile, the other infrared sensor detects, as a detected-temperature, a temperature affected by the heat-generating object. Especially if the surface of the obstacle has high reflectance, the temperature of a different position is detected. In this case, the detected-temperatures of the infrared sensors are corrected on a basis of the temperatures of the objects different between the two infrared sensors. It is thus not possible to correct the detected-temperatures of the infrared sensors accurately.

[0007] The present invention has been made in view of the aforementioned circumstances, and it is desirable to provide a temperature distribution detection technique capable of correcting detected-temperatures between infrared sensors accurately.

Summary

[0008] In view of the above-mentioned circumstances, according to an embodiment of the present invention, there is provided a temperature distribution detecting apparatus that obtains thermographies from a plurality of infrared sensors arranged in a space, and detects a temperature distribution of the space on a basis of detected-temperatures detected from the thermographies, the temperature distribution detecting apparatus including: a temperature-stable region determining unit that determines, as temperature-stable regions, regions in overlapped regions, in which changes of temperature distributions are smaller than a threshold, of thermographies of two adjacent infrared sensors out of the plurality of infrared sensors, the overlapped regions of the thermographies overlapping with each other; a temperature difference calculating unit that calculates a temperature difference between representative detected-temperatures detected in the temperature-stable regions of the thermographies of the two adjacent infrared sensors; and a temperature distribution generating unit that estimates a relative temperature error between the plurality of infrared sensors on a basis of the temperature difference, corrects the detected-temperatures obtained from the thermographies of the plurality of infrared sensors on a basis of the obtained

relative temperature error, and thereby generates a temperature distribution of the space.

[0009] Further, according to an embodiment of the temperature distribution detecting apparatus of the present invention, the temperature-stable region determining unit detects a heat-generating object, which is moving, from the overlapped regions, and determines, as the temperature-stable regions, regions of the overlapped regions without the heat-generating object, in each of which change of the temperature distribution is smaller than the threshold.

[0010] Further, according to an embodiment of the temperature distribution detecting apparatus of the present invention, the temperature distribution generating unit excludes, where a certain correlation is not obtained between temporal changes of the representative detected-temperatures of the two adjacent infrared sensors, a temperature difference between the two infrared sensors from the temperature difference, from which the relative temperature error is estimated.

[0011] Further, according to an embodiment of the present invention, there is provided a method of detecting a temperature distribution, the method being used by a temperature distribution detecting apparatus that obtains thermographies from a plurality of infrared sensors arranged in a space, and detects a temperature distribution of the space on a basis of detected-temperatures detected from the thermographies, the method including: by a temperature-stable region determining unit, determining, as temperature-stable regions, regions in overlapped regions, in which changes of temperature

distributions are smaller than a threshold, of thermographies of two adjacent infrared sensors out of the plurality of infrared sensors, the overlapped regions of the thermographies overlapping with each other; by a temperature difference calculating unit, calculating a temperature difference between representative detected-temperatures detected in the temperature-stable regions of the thermographies of the two adjacent infrared sensors; and by a temperature distribution generating unit, estimating a relative temperature error between the plurality of infrared sensors on a basis of the temperature difference, correcting the detected-temperatures obtained from the thermographies of the plurality of infrared sensors on a basis of the obtained relative temperature error, and thereby generating a temperature distribution of the space.

[0012] According to the present invention, the temperature difference between the representative detected-temperatures, which are detected from the temperature-stable regions whose temperature distributions are stable in the overlapped regions, is used to estimate the relative temperature error. As a result, the relative temperature error is estimated on a basis of temperatures unaffected by obstacles and a heat-generating object such as a person. It is thus possible to correct the detected-temperatures of the infrared sensors with a high degree of accuracy.

These and other objects, features and advantages of the present disclosure will become more apparent in light of the following detailed description of best mode embodiments thereof, as illustrated in the accompanying

drawings.

Brief Description of Drawings

[0013] Fig. 1 is a block diagram showing a configuration of a temperature distribution detecting apparatus;

Fig. 2 shows an example of infrared sensors arranged in a space;

Fig. 3 is a diagram illustrating detection ranges of infrared sensors; and

Fig. 4 is a flowchart showing a temperature distribution detection process.

Detailed Description of Embodiments

[0014] Hereinafter, an embodiment of the present technology will be described with reference to the drawings.

[Temperature distribution detecting apparatus]

Firstly, the temperature distribution detecting apparatus 10 of an embodiment of the present invention will be described with reference to Fig. 1. Fig. 1 is a block diagram showing a configuration of a temperature distribution detecting apparatus.

[0015] The temperature distribution detecting apparatus 10 as a whole is an information processing apparatus such as a server apparatus, a personal computer, and an industrial controller. The temperature distribution detecting apparatus 10 has functions of obtaining thermographies from the plurality of infrared sensors AS arranged in the space 20 as a target via the communication line L1, estimating a relative temperature error between the detected-temperatures of the infrared sensors AS on a basis of the detected-temperatures

detected from the thermographies, correcting the detected-temperatures on a basis of the relative temperature error, and thereby generating temperature distribution data of the space 20.

5 [0016] Fig. 2 shows an example of infrared sensors arranged in a space. (a) of Fig. 2 is a plan view showing the space. (b) of Fig. 2 is a II-II cross-sectional view of (a) of Fig. 2. Here, the ceiling 21 of the space 20 has a rectangular shape in a plan view. The
10 plurality of infrared sensors AS such as thermopile array sensors are arranged at regular intervals in a matrix. The infrared sensors AS are arranged on the intersections of the matrix. Each infrared sensor AS has an approximately-square detection range R in a vertical
15 direction from the ceiling 21 toward the floor 22.

[0017] Fig. 3 is a diagram illustrating detection ranges of infrared sensors. In this example, there are overlapped regions Q on the floor 22. On the overlapped region Q, a part of the detection range R of one infrared
20 sensor AS1 overlaps with a part of the detection range R of the adjacent infrared sensor AS2. Note that, in the aforementioned example, each infrared sensor AS has the detection range R in the vertical direction from the ceiling 21 toward the floor 22. Alternatively, each
25 infrared sensor AS may have the detection range R not in the vertical direction but in an inclined direction. Further, the infrared sensors AS may be attached on not the ceiling 21 but the floor 22 or the walls 23.

[0018] As shown in Fig. 3, the obstacle S such as a
30 separation is placed on the overlapped region Q, and the heat-generating object H such as a person is at the

infrared sensor AS2 side of the obstacle S. In this case, the thermography P1 of the infrared sensor AS1 has no heat-generating object H, and the thermography P2 of the infrared sensor AS2 has the heat-generating object H.

5 As a result, the detected-temperature T1 of the overlapped region Q1 of the thermography P1 corresponding to the overlapped region Q is different from the detected-temperature T2 of the overlapped region Q2 of the thermography P2 corresponding to the overlapped
10 region Q.

[0019] According to the present invention, changes of temperature distributions of the overlapped regions Q1, Q2 of the thermographies P1, P2 are monitored. There are determined, as the temperature-stable regions V1, V2, the
15 overlapped regions Q1, Q2, in which the changes of the temperature distributions are smaller than a threshold. The relative detected-temperatures of the plurality of infrared sensors AS are corrected on a basis of the obtained detected-temperatures obtained from the
20 temperature-stable regions V1, V2.

[0020] Next, with reference to Fig. 1, a configuration of the temperature distribution detecting apparatus 10 of the present embodiment will be described in detail.

The temperature distribution detecting apparatus 10
25 mainly includes, as functional units, the sensor I/F unit 11, the thermography obtaining unit 12, the memory unit 13, the temperature-stable region determining unit 14, the temperature difference calculating unit 15, the temperature distribution generating unit 16, and the
30 communication I/F unit 17. A central processing unit (CPU) executes programs to realize the temperature-stable

region determining unit 14, the temperature difference calculating unit 15, and the temperature distribution generating unit 16 out of those functional units.

[0021] The sensor I/F unit 11 has a function of sending and receiving data to and from the infrared sensors AS via the communication line L1.

The thermography obtaining unit 12 has a function of obtaining thermographies at predetermined intervals from the infrared sensors AS via the sensor I/F unit 11 and the communication line L1, and storing the thermographies in the memory unit 13 in time series.

[0022] The memory unit 13 includes memory devices such as a hard disk and a semiconductor memory. The memory unit 13 has a function of storing various processing data and programs used for the temperature distribution detection process. Examples of such data include arranged positions of the infrared sensors AS, thermographies, relative temperature errors, temperature distribution data, and the like.

[0023] The temperature-stable region determining unit 14 has a function of monitoring temporal changes of temperature distributions of the overlapped regions Q1, Q2 of the thermographies P1, P2 of the two adjacent infrared sensors AS1, AS2, which are stored in the memory unit 13, corresponding to the overlapped regions Q of the thermographies P1, P2 overlapping with each other. The temperature-stable region determining unit 14 has a function of determining, as the temperature-stable regions V1, V2, regions in the overlapped regions Q1, Q2, in which temporal changes of temperatures are smaller than a threshold, the positions of the regions being

coincide with each other.

[0024] At this time, the temperature-stable region determining unit 14 may detect a heat-generating object, which is moving, from the overlapped regions Q1, Q2, and determine, as the temperature-stable regions V1, V2, regions of the overlapped regions Q1, Q2 without the heat-generating object, in each of which change of the temperature distribution is smaller than the threshold.

[0025] The temperature difference calculating unit 15 has a function of calculating the temperature difference ΔT between the representative detected-temperatures T1, T2 detected in the temperature-stable regions V1, V2 of the thermographies P1, P2 of the two adjacent infrared sensors AS1, AS2.

[0026] The temperature distribution generating unit 16 has functions of estimating a relative temperature error between the plurality of infrared sensors AS on a basis of the temperature difference ΔT calculated by the temperature difference calculating unit 15, correcting the detected-temperatures obtained from the thermographies of the plurality of infrared sensors AS on a basis of the obtained relative temperature error, thereby generating a temperature distribution of the space 20, and storing the obtained temperature distribution data in the memory unit 13.

[0027] At this time, the temperature distribution generating unit 16 may exclude, where a certain correlation is not obtained between temporal changes of the representative detected-temperatures T1, T2 of the two adjacent infrared sensors AS1, AS2, a temperature difference between the two infrared sensors AS1, AS2 from

the temperature difference ΔT , from which the relative temperature error is estimated.

[0028] The communication I/F unit 17 sends and receives data to and from the host system 30 via the communication line L2, and thereby has a function of sending and receiving various data to and from the host system 30. Examples of such data include temperature distribution data stored in the memory unit 13 and the like.

[0029] [Behavior of present embodiment]

Next, with reference to Fig. 4, a behavior of the temperature distribution detecting apparatus 10 of the present embodiment will be described. Fig. 4 is a flowchart showing a temperature distribution detection process.

In an example described below, the memory unit 13 already stores, in time series, thermographies imaged by the infrared sensors AS.

[0030] Firstly, the temperature-stable region determining unit 14 selects an unselected pair of the two adjacent infrared sensors AS1, AS2 out of the infrared sensors AS (Step 100), and obtains the thermographies P1, P2 of the two adjacent infrared sensors AS1, AS2 from the memory unit 13 (Step 101).

Subsequently, the temperature-stable region determining unit 14 determines, as the temperature-stable regions V1, V2, regions in the overlapped regions Q1, Q2 of the thermographies P1, P2, in which temporal changes of temperatures are smaller than a threshold, the positions of the regions being coincide with each other (Step 102).

[0031] Next, the temperature difference calculating unit 15 detects the representative detected-temperatures T1, T2 in the temperature-stable regions V1, V2 of the thermographies P1, P2 of the two adjacent infrared sensors AS1, AS2 (Step 103), and calculates the temperature difference ΔT between the representative detected-temperatures T1, T2 (Step 104). The representative detected-temperatures T1, T2 may be representative temperatures obtained on a basis of statistical processing of the temperature distributions of the temperature-stable regions V1, V2, and may be average values, maximum values, minimum values, median values, or the like.

[0032] After that, the temperature-stable region determining unit 14 determines whether or not all the pairs of the two adjacent infrared sensors AS1, AS2 are selected (Step 105). If there is an unselected pair (Step 105: NO), the process returns to Step 100.

[0033] Meanwhile, where all the pairs of the two adjacent infrared sensors AS1, AS2 are selected (Step 105: YES), the temperature distribution generating unit 16 estimates a relative temperature error between the plurality of infrared sensors AS on a basis of the temperature difference ΔT calculated by the temperature difference calculating unit 15 (Step 106).

A method of estimating a relative temperature error disclosed in Japanese Patent Application Laid-open No. 2014-016223 may be used. For example, an equation indicating a relation between a relative temperature error, which is between the infrared sensor AS0 as a reference and each infrared sensor AS, and the

temperature difference ΔT , which is calculated for each pair of the infrared sensors AS, is generated for each pair. The system of the equations are solved by using the method of least squares. As a result, the relative temperature errors are estimated.

[0034] Next, the temperature distribution generating unit 16 corrects the detected-temperatures obtained from the thermographies of the plurality of infrared sensors AS on a basis of the obtained relative temperature error, thereby generates a temperature distribution of the space 20, and stores the obtained temperature distribution data in the memory unit 13 (Step 107). A series of the temperature distribution detection process is finished.

[0035] Note that, for easier understanding, in the aforementioned example with reference to Fig. 4, the relative temperature error between the infrared sensors AS and the temperature distribution of the space 20 are obtained simultaneously. However, the method is not limited to this. Typically, a relative temperature error between the infrared sensors AS is relatively stable, and may not be changed in a short time. Therefore, in general, relative temperature errors are estimated at predetermined intervals, the relative temperature errors are stored in the memory unit 13, and the relative temperature errors are read from the memory unit 13 and are used to obtain the temperature distribution.

[0036] [Effects of the present embodiment]

As described above, according to the present embodiment, the temperature-stable region determining unit 14 determines, as the temperature-stable regions V1, V2, regions in the overlapped regions Q1, Q2, in which

changes of temperature distributions are smaller than a threshold, of the thermographies P1, P2 of the two adjacent infrared sensors AS1, AS2 out of the plurality of infrared sensors AS, the overlapped regions Q1, Q2 of the thermographies P1, P2 overlapping with each other. The temperature difference calculating unit 15 calculates the temperature difference ΔT between the representative detected-temperatures T1, T2 detected in the temperature-stable regions V1, V2 of the thermographies P1, P2 of the two adjacent infrared sensors AS1, AS2. The temperature distribution generating unit 16 estimates a relative temperature error between the plurality of infrared sensors AS on a basis of the temperature difference ΔT , corrects the detected-temperatures obtained from the thermographies of the plurality of infrared sensors AS on a basis of the obtained relative temperature error, and thereby generates a temperature distribution of the space 20.

[0037] As a result, the temperature difference ΔT between the representative detected-temperatures T1, T2, which are detected from the temperature-stable regions V1, V2 whose temperature distributions are stable in the overlapped regions Q1, Q2, is used to estimate the relative temperature error. As a result, the relative temperature error is estimated on a basis of temperatures unaffected by obstacles and a heat-generating object such as a person. It is thus possible to correct the detected-temperatures of the infrared sensors AS with a high degree of accuracy.

[0038] Further, according to the present embodiment, the temperature-stable region determining unit 14 may

detect a heat-generating object, which is moving, from the overlapped regions Q1, Q2, and determines, as the temperature-stable regions V1, V2, regions of the overlapped regions Q1, Q2 without the heat-generating object, in each of which change of the temperature distribution is smaller than the threshold. As a result, the temperature-stable region determining unit 14 determines, as the temperature-stable regions V1, V2, regions of the overlapped regions Q1, Q2 without the heat-generating object such as a person. It is thus possible to estimate the relative temperature error with a higher degree of accuracy. Further, in the past, the relative temperature error estimation is executed at night or when there is no person in the space so as not to be affected by heat-generating objects. To the contrary, according to the present embodiment, the relative temperature error estimation can be executed at arbitrary timing, e.g., during daytime when there is a person in the space, because the relative temperature error estimation of the present embodiment is less affected by heat-generating objects.

[0039] Further, in the present embodiment, the temperature distribution generating unit 16 may exclude, where a certain correlation is not obtained between temporal changes of the representative detected-temperatures T1, T2 of the two adjacent infrared sensors AS1, AS2, a temperature difference ΔT between the two infrared sensors AS1, AS2 from the temperature difference ΔT , from which the relative temperature error is estimated.

[0040] As a result, it is possible to predict that one

or both of the temperature-stable regions V1, V2, from which the representative detected-temperatures T1, T2 are detected, is/are affected by something and is/are a temperature-change region/temperature-change regions.

5 The temperature distribution generating unit 16 can exclude the temperature difference ΔT from the temperature difference ΔT , from which the relative temperature error is estimated. It is thus possible to estimate the relative temperature error with a higher
10 degree of accuracy. Note that it is not necessary to obtain all the temperature differences ΔT between all the pairs of the two adjacent infrared sensors AS1, AS2. If each of all the infrared sensors AS has any one pair, it is possible to estimate relative temperature errors of
15 all the infrared sensors AS.

[0041] [Extension of embodiment]

It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on
20 design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

What is claimed is:

1. A temperature distribution detecting apparatus that obtains thermographies from a plurality of infrared sensors arranged in a space, and detects a temperature distribution of the space on a basis of detected-
5 temperatures detected from the thermographies, the temperature distribution detecting apparatus comprising:

a temperature-stable region determining unit that determines, as temperature-stable regions, regions in
10 overlapped regions, in which changes of temperature distributions are smaller than a threshold, of thermographies of two adjacent infrared sensors out of the plurality of infrared sensors, the overlapped regions of the thermographies overlapping with each other;

15 a temperature difference calculating unit that calculates a temperature difference between representative detected-temperatures detected in the temperature-stable regions of the thermographies of the two adjacent infrared sensors; and

20 a temperature distribution generating unit that estimates a relative temperature error between the plurality of infrared sensors on a basis of the temperature difference,

25 corrects the detected-temperatures obtained from the thermographies of the plurality of infrared sensors on a basis of the obtained relative temperature error, and thereby

generates a temperature distribution of the space.

30 2. The temperature distribution detecting apparatus according to claim 1, wherein

the temperature-stable region determining unit
detects a heat-generating object, which is
moving, from the overlapped regions, and
determines, as the temperature-stable regions,
5 regions of the overlapped regions without the heat-
generating object, in each of which change of the
temperature distribution is smaller than the threshold.

3. The temperature distribution detecting apparatus
according to claim 1 or claim 2, wherein

10 the temperature distribution generating unit
excludes, where a certain correlation is not obtained
between temporal changes of the representative detected-
temperatures of the two adjacent infrared sensors, a
temperature difference between the two infrared sensors
15 from the temperature difference, from which the relative
temperature error is estimated.

4. A method of detecting a temperature distribution,
the method being used by a temperature distribution
detecting apparatus that obtains thermographies from a
20 plurality of infrared sensors arranged in a space, and
detects a temperature distribution of the space on a
basis of detected-temperatures detected from the
thermographies, the method comprising:

by a temperature-stable region determining unit,
25 determining, as temperature-stable regions, regions in
overlapped regions, in which changes of temperature
distributions are smaller than a threshold, of
thermographies of two adjacent infrared sensors out of
the plurality of infrared sensors, the overlapped regions
30 of the thermographies overlapping with each other;

by a temperature difference calculating unit,

calculating a temperature difference between
representative detected-temperatures detected in the
temperature-stable regions of the thermographies of the
two adjacent infrared sensors; and

5 by a temperature distribution generating unit,
 estimating a relative temperature error between
the plurality of infrared sensors on a basis of the
temperature difference,

 correcting the detected-temperatures obtained
10 from the thermographies of the plurality of infrared
sensors on a basis of the obtained relative temperature
error, and thereby

 generating a temperature distribution of the
space.

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