

DESCRIPTION

Title of Invention

REFRIGERATOR

5 Technical Field

[0001]

The present disclosure relates to a refrigerator that includes a storage compartment having a door designed to open and close and storing stored items at adjusted temperatures, as well as a door opening-closing detector.

10 Background Art

[0002]

A conventional refrigerator stores a number of times at which a drawer of an ice-making compartment is opened every hour for seven days, adds up the numbers of times for every time periods, and changes its ice-making capacity in response to the number of door-opening times per unit-time length. For instance, during a time period when the number of door-opening times is small, such as less than five times per hour, the refrigerator determines that an amount of ice usage is small and operates at a low ice-making capacity. During a time period when the number of door-opening times is medium, such as five times or greater and less than 15 times per hour, the refrigerator operates at a medium ice-making capacity. During a time period when the number of door-opening times is large, such as 15 times or greater per hour, the refrigerator operates at a high ice-making capacity. In this way, the refrigerator operates in response to a user's usage conditions to reduce waste in cooling (for example, refer to Patent Literature 1).

25 [0003]

Another conventional refrigerator divides 24 hours a day into predetermined time zones, e.g., one-hour intervals, and counts a number of times a door of the refrigerator is opened and closed for every time zone. The refrigerator determines a time zone in which a user does not open the refrigerator, a time zone in which the user opens the refrigerator, and a time zone in which the user opens the refrigerator

with low frequency and defrosts during the time zone in which the user does not open the refrigerator (for example, refer to Patent Literature 2).

Citation List

Patent Literature

[0004]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2017-15344

Patent Literature 2: Japanese Unexamined Patent Application Publication No. HEI05-248756

Summary of Invention

Technical Problem

[0005]

According to a method of operating the refrigerator in response to the user's usage conditions based on the number of door-opening times by the technique of Patent Literature 1, a number of times the drawer is opened and closed is recorded even in the middle of the night when the user, for example, happens to get up after falling asleep and opens and closes the refrigerator. This makes the refrigerator unable to set a substantial time zone, e.g., about six hours, during which the user opens the refrigerator with low frequency. This also presents a possibility that a controlled task required to be performed over a plurality of hours, e.g., four hours, is interrupted halfway.

[0006]

According to the technique of Patent Literature 1, a threshold used to determine a level of door-opening frequency is specified depending on the number of door-opening times. As a result, if different users have different absolute values of the numbers of door-opening times in daily life, the threshold may not provide intended accuracy. For instance, let us assume that a user A opens the drawer at maximum five times or so per unit-time length. Meanwhile, let us assume that the number of times a user B opens the drawer per unit-time length reaches up to 15 times or so. When the number of door-opening times being 10 times or greater is

determined as high door-opening frequency by a specified threshold, the door-opening frequency of the user A can be constantly determined as low throughout a day. When the door-opening frequency changes per unit-time length, an operating state of the refrigerator changes moment by moment. This can contribute to a deterioration in energy consumption performance.

[0007]

According to a method of operating the refrigerator in response to the user's usage conditions based on the number of door-opening times by the technique of Patent Literature 2, families such as double-income households where a day worker and a night worker coexist, which have been common in recent years, open and close the refrigerator door in no small numbers even at nighttime. As a result, in some cases, it is difficult to find a time period made up of a plurality of hours in which the user does not open the refrigerator. This creates a possibility that defrosting or similar operation performed during a time zone in which the user does not open the refrigerator cannot be performed throughout a day.

[0008]

These problems arise from inability of the refrigerator to predict a time period with low door-opening frequency based on the user's living conditions.

[0009]

An object of the present disclosure, accomplished to solve the problems described above, is to provide a refrigerator capable of predicting a time period in which a user opens the refrigerator with low frequency based on the user's living conditions.

Solution to Problem

[0010]

A refrigerator according to an embodiment of the present disclosure includes: a storage compartment including a door designed to open and close and being configured to cool and preserve stored items; a door opening-closing detector to detect opening and closing of the door of the storage compartment; a storage unit to receive data about opening and closing of the door detected with the door opening-

closing detector and store a number of times the door is opened and closed per given unit-time length for a given number of days; and a controller, wherein the controller calculates an average value for the given number of days that is an average of numbers of times the door is opened and closed each given unit-time length for the given number of days from numbers of door opening-closing times stored for every given unit-time lengths in the storage unit, the controller calculates a latest-time-lengths total value that is a sum of the average values for the given number of days of the numbers of door opening-closing times for latest time lengths specified from a starting point of each unit-time length for every unit-time length, the controller calculates an immediately following-time-lengths total value that is a sum of the average values for the given number of days of the numbers of door opening-closing times for immediately following time lengths specified from a starting point of each unit-time length for every unit-time length, and the controller determines a sectioned zone of specified time lengths in which the storage compartment is opened and closed with low frequency based on one of or both of the latest-time-lengths total value and the immediately following-time-lengths total value.

Advantageous Effects of Invention

[0011]

In the refrigerator according to an embodiment of the present disclosure, the controller determines a sectioned zone of the specified time lengths in which the storage compartment is opened and closed with low frequency based on one of or both of the latest-time-lengths total value and the immediately following-time-lengths total value. Thus, the controller can predict a given time period in which a user opens the compartment door with low frequency based on the user's living conditions.

Brief Description of Drawings

[0012]

[Fig. 1] Fig. 1 is a perspective view illustrating a refrigerator according to Embodiment 1 of the present disclosure.

[Fig. 2] Fig. 2 is an elevation view illustrating the refrigerator according to Embodiment 1 of the present disclosure.

[Fig. 3] Fig. 3 is a functional block diagram illustrating the refrigerator according to Embodiment 1 of the present disclosure.

[Fig. 4] Fig. 4 is a block diagram illustrating a controller according to Embodiment 1 of the present disclosure.

5 [Fig. 5] Fig. 5 is a flowchart illustrating a control process according to Embodiment 1 of the present disclosure.

[Fig. 6] Fig. 6 is a graph illustrating a control result 1 according to Embodiment 1 of the present disclosure.

10 [Fig. 7] Fig. 7 is a graph illustrating a control result 2 according to Embodiment 1 of the present disclosure.

[Fig. 8] Fig. 8 is a graph illustrating a control result 3 according to Embodiment 1 of the present disclosure.

[Fig. 9] Fig. 9 is a graph illustrating special temperature control according to Embodiment 1 of the present disclosure.

15 [Fig. 10] Fig. 10 is a flowchart illustrating the special temperature control according to Embodiment 1 of the present disclosure.

[Fig. 11] Fig. 11 is a graph illustrating redoing of the special temperature control according to Embodiment 1 of the present disclosure.

20 [Fig. 12] Fig. 12 is a graph illustrating temperature equalization control according to Embodiment 1 of the present disclosure.

Description of Embodiments

[0013]

Embodiments of the present disclosure will now be described with reference to the drawings. In the drawings, identical or equivalent elements are denoted by
25 identical reference numerals, and this applies to the full text of the specification. In cross-sectional views, hatching is omitted as appropriate for the sake of visibility. Forms of constituent elements shown in the full text of the specification are merely examples and are not intended to limit the subject matter described in the appended claims.

30 [0014]

Embodiment 1.

Fig. 1 is a perspective view illustrating a refrigerator 1 according to Embodiment 1 of the present disclosure. Fig. 2 is an elevation view illustrating the refrigerator 1 according to Embodiment 1 of the present disclosure.

[0015]

As shown in Figs. 1 and 2, the refrigerator 1 includes a refrigerator compartment 121, an ice-making compartment 122, a freezer compartment 123, a freezer compartment 124, and a vegetable compartment 125. The freezer compartment 123 switches between a refrigeration temperature range around -18 degrees C and a mild refrigeration temperature range around -7 degrees C. The refrigerator compartment 121, the ice-making compartment 122, the freezer compartment 123, the freezer compartment 124, and the vegetable compartment 125 are each a storage compartment 12 including a door designed to open and close and being configured to cool and preserve stored items such as food. The refrigerator 1 may include at least one of the storage compartments 12. When the refrigerator 1 includes a plurality of the storage compartments 12, the plurality of the storage compartments 12 may be disposed in any manner.

[0016]

The refrigerator 1 includes a door switch 131 configured to be turned on or off in response to opening or closing of the door of any of the refrigerator compartment 121, the ice-making compartment 122, and the freezer compartment 123. The refrigerator 1 includes a drawer switch 132 configured to be turned on or off in response to opening or closing of the drawer of the freezer compartment 124. The refrigerator 1 includes a drawer switch 133 configured to be turned on or off in response to opening or closing of the drawer of the vegetable compartment 125. The door switch 131, the drawer switch 132, and the drawer switch 133 constitute a door opening-closing detector 13 used to detect opening and closing of the door of any of the storage compartments 12.

[0017]

Fig. 3 is a functional block diagram illustrating the refrigerator 1 according to Embodiment 1 of the present disclosure. As shown in Fig. 3, the refrigerator 1 includes the door opening-closing detector 13 to detect opening and closing of the door of any of the storage compartments 12. The refrigerator 1 has a storage unit 111 to receive door-opening signals sent from the door opening-closing detector 13 and store a number of times the door is opened and closed per unit-time length for a given number of days. The refrigerator 1 includes a controller 11. The controller 11 includes the storage unit 111. The refrigerator 1 includes a cooling unit 14 to cool the plurality of the storage compartments 12. The refrigerator 1 includes a defrosting heater 15 to defrost the cooling unit 14.

[0018]

<Controller 11>

Fig. 4 is a block diagram illustrating the controller 11 according to Embodiment 1 of the present disclosure. The controller 11 is responsible for controlling parts including a drive device for the cooling unit 14 and the defrosting heater 15. As shown in Fig. 4, the controller 11 is a processing circuit including a microcomputer that has a central processing unit (CPU), memory such as read only memory (ROM) and random-access memory (RAM), and an input/output device such as an I/O port. The storage unit 111 is formed in the RAM.

[0019]

The controller 11 calculates a 7-days average value that is an average of numbers of times the door is opened and closed each hour for seven days one hour by one hour from numbers of door opening-closing times stored for every one hours in the storage unit 111. The 7-days average value may be an average value for a given number of days, the seven days may be the given number of days, and the every one hours may be every given unit-time lengths. The controller 11 calculates a latest-hours total value that is a sum of the 7-days average values of the numbers of door opening-closing times for the latest six hours that are hours specified from a starting point of each hour for every one hour. The controller 11 calculates an immediately following-hours total value that is a sum of the 7-days average values of

the numbers of door opening-closing times for the immediately following six hours that are hours specified from a starting point of each hour for every unit-time length. The controller 11 determines a sectioned zone of six hours in which the user opens and closes any of the storage compartments 12 with low frequency based on one of or both of the latest 6-hours total value and the immediately following 6-hours total value.

[0020]

<Control for inferring living conditions>

Fig. 5 is a flowchart illustrating a control process according to Embodiment 1 of the present disclosure. As shown in Fig. 5, the controller 11 stores the number of door opening-closing times for every unit-time length in the storage unit 111 in step S1. The controller 11 divides a day by one hour into a total of 24 blocks from a 0th block to a 23rd block and stores the numbers of door-opening times for the respective blocks by door into the storage unit 111. The controller 11 executes the step S1 until data is stored for seven days. When the period for which the data is stored exceeds seven days, the controller 11 overwrites an oldest piece of the data in sequence to store new data in the storage unit 111. By repeating data storing of step S1, the controller 11 always stores the numbers of door opening-closing times for every one hours for latest seven days by storage compartment in the storage unit 111.

[0021]

Preferably, the unit-time length by which a day is divided is basically one hour and data is stored accordingly. This enables the refrigerator to satisfactorily infer the user's living conditions. However, if door opening-closing frequency needs to be analyzed in more detail, the unit-time length may be specified as 30 minutes or so. If door opening-closing frequency is analyzed in a broader way with consideration given to a memory capacity of the storage unit 111, the unit-time length may be specified as eight hours or so.

[0022]

In step S2, the controller 11 calculates a 7-days average value of door opening-closing times for every one hour.

[0023]

The controller 11 stores the numbers of door-opening times for 24 hours from the 0th block to the 23rd block a day by a unit-time length of one hour. At a time when the controller 11 finishes storing the number of door-opening times for the 23rd block on one day into the storage unit 111 and shifts to a storage location of the 0th block on the following day, the controller 11 adds up the number of times each of the storage compartments 12 is opened in every block.

[0024]

Specifically, the controller adds up the numbers of times the respective doors of the refrigerator compartment 121, the ice-making compartment 122, the freezer compartment 123, the freezer compartment 124, and the vegetable compartment 125 are opened in the 0th block. The controller performs similar calculations for the remaining 1st block to the 23rd block.

[0025]

Next, the controller 11 multiplies 7-days average values calculated previously from data in the 0th block to the 23rd block for seven days by 6, adds the numbers of door-opening times calculated a moment ago for the latest one day to the multiplied values block by block, and divides block-by-block results of the addition by 7. The controller 11 stores results of this calculation as latest 7-days average values in the storage unit 111.

[0026]

In preparation for a time when the controller shifts from the 23rd block on one day to the 0th block on the following day for the first time after turning-on of the power to the refrigerator 1, initial 7-days average values are specified in the storage unit 111 in advance. Preferably, all the initial values are basically specified as 0. However, initial 7-days average values may be specified by referring to, for example, market data about door opening-closing frequency at ordinary households.

[0027]

The initial values may be specified as numbers of opening-closing times, such as 10,000 times, that cannot occur in actual applications. However, initial values that

deviate substantially from values in actual applications require extra time until actual door-opening frequency can be estimated and thus are unfavorable.

[0028]

In step S3, the controller 11 calculates a latest-hours total value that is a sum of 7-days average values of the numbers of door-opening times for the latest six blocks or six hours that are hours specified from a starting point of each block. In this example, after a time period with low door-opening frequency is estimated, the controller executes a control process, described later, that spans up to six hours in the time period. Thus, the specified hours are six hours.

[0029]

Fig. 6 is a graph illustrating a control result 1 according to Embodiment 1 of the present disclosure. Fig. 7 is a graph illustrating a control result 2 according to Embodiment 1 of the present disclosure. Fig. 8 is a graph illustrating a control result 3 according to Embodiment 1 of the present disclosure.

[0030]

With reference to Fig. 7, the latest-hours total value will be described. In Fig. 7, the horizontal axis shows each unit-time length from the 0th block to the 23rd block, and the vertical axis shows a 7-days average value of the numbers of door-opening times for each unit-time length. A latest 6-hours total value on the 0th block is 3 times, which is a sum of the 7-days average values in the six blocks in total, namely 0 door-opening times in the starting-point 0th block, 0 door-opening times in the first preceding 23rd block, 0 door-opening times in the second preceding 22nd block, 0 door-opening times in the third preceding 21st block, 0 door-opening times in the fourth preceding 20th block, and 3 door-opening times in the fifth preceding 19th block. The controller performs similar calculations for the remaining 1st block to the 23rd block to calculate latest 6-hours total values for all the 24 blocks.

[0031]

In step S4, the controller 11 compares the latest-hours total values calculated above and determines whether or not a number of minimums out of the numbers of door opening-closing times is one. When one minimum is present out of the

numbers of door opening-closing times, the controller transitions to step S5. When a plurality of minimums are present out of the numbers of door opening-closing times, the controller transitions to step S6.

[0032]

5 In step S5, the controller 11 determines that a zone of latest six hours specified from a starting point of a block where one minimum of door opening-closing times exists, i.e., from the sixth preceding block through the first preceding block, is a time period in which the user opens the refrigerator 1 with low frequency. In other words, as shown in Fig. 6, the controller 11, when the latest 6-hours total value on the 3rd
10 block is only one minimum, determines that the six hours from the sixth preceding 21st block to the 2nd block, the first block previous to the 3rd block, are a time zone in which the user opens the refrigerator 1 with low frequency. In other words, when only one minimum latest-hours total value is present, the controller 11 sets a start time of the 3rd block, one first unit-time length in which the minimum latest-hours total
15 value is calculated, as a reference point and determines that a period between six hours before the start time of the 3rd block and the start time of the 3rd block is a zone in which the user opens and closes any of the storage compartments 12 with low frequency.

[0033]

20 In step S6, the controller 11 calculates an immediately following-hours total value that is a sum of 7-days average values for the immediately following six blocks or six hours that are a given period specified from a starting point of each block. Specifically, as shown in Fig. 7, an immediately following 6-hours total value on the 0th block is calculated as 11 times, which is a sum of the 7-days average values in
25 the six blocks in total, namely 0 door-opening times in the starting-point 0th block, 0 door-opening times in the first following 1st block, 0 door-opening times in the second following 2nd block, 0 door-opening times in the third following 3rd block, 3 door-opening times in the fourth following 4th block, and 8 door-opening times in the fifth following 5th block. The controller 11 performs similar calculations for the remaining

1st block to the 23rd block to calculate immediately following 6-hours total values for all the 24 blocks.

[0034]

In step S7, the controller 11 determines whether or not a number of maximums out of the immediately following 6-hours total values in two or more blocks where minimum latest 6-hours total values are present is one. When one maximum is present out of the numbers of door opening-closing times, the controller transitions to step S5. When a plurality of maximums are present out of the numbers of door opening-closing times, the controller transitions to step S8.

[0035]

In step S5 to which the controller has transitioned from step S7, the controller 11 determines that a zone of latest six hours, a given period specified from a starting point of a block where one maximum immediately following 6-hours total value exists, out of the two or more blocks where minimum latest 6-hours total values are present, i.e., from the sixth preceding block through the first preceding block, is a time period in which the user opens the refrigerator 1 with low frequency. In other words, in an example of Fig. 7, the latest 6-hours total values in the 1st block through the 3rd block are minimum 0 times and the immediately following 6-hours total value in the 3rd block out of the three blocks is maximum 22 times. Thus, with the 3rd block set as a starting point, the controller determines that the six hours from the sixth preceding 21st block to the first preceding 2nd block are a time zone in which the user opens the refrigerator 1 with low frequency. In other words, when the plurality of the minimum latest-hours total values are present and one maximum immediately following-hours total value is present, the controller 11 sets the start time of the 3rd block, one second unit-time length in which the maximum immediately following-hours total value is calculated, as a reference point and determines that a period between six hours before the start time of the 3rd block and the start time of the 3rd block is a zone in which the user opens and closes any of the storage compartments 12 with low frequency.

[0036]

In step S8, when a plurality of maximum immediately following 6-hours total values are present in two or more blocks in which minimum latest 6-hours total values are present, the controller 11 sets a unit-time length of a block that is earliest and lowest in serial number out of the blocks in each day as a starting point and determines a time period in which the user opens the refrigerator 1 with low frequency. In an example of Fig. 8, the unit-time length in which the minimum latest 6-hours total value and the maximum immediately following 6-hours total value are present is the 6th block and the 18th block. In this case, the controller sets the 6th block, which is earliest and lowest in serial number out of the blocks in the day, as a starting point and determines a time zone in which the user opens the refrigerator 1 with low frequency. In other words, when the plurality of the minimum latest-hours total values are present and the plurality of the maximum immediately following-hours total values are present, the controller 11 sets a start time of the 6th block, one third unit-time length in which the maximum immediately following-hours total value is calculated, which is earliest and lowest in serial number out of the two or more blocks where maximum immediately following 6-hours total values are present, as a reference point and determines that a period between six hours before the start time of the 6th block and the start time of the 6th block is a zone in which the user opens and closes any of the storage compartments 12 with low frequency.

[0037]

As described above, Fig. 6 shows a case in which only one unit-time length where one minimum latest 6-hours total value is present exists. Fig. 7 shows a case that is expected to occur at highest probability in which unit-time lengths where a plurality of minimum latest 6-hours total values and only one maximum immediately following 6-hours total value are present exist. Fig. 8 shows a case in which two or more unit-time lengths where a plurality of minimum latest 6-hours total values and a plurality of maximum immediately following 6-hours total values are present exist.

[0038]

As described above, the controller predicts changes in level of door-opening frequency by focusing on latest-hours total values to find a time until which the

refrigerator 1 is opened with lowest frequency and immediately following-hours total values to find a time from which the refrigerator 1 is opened with highest frequency. This enables the refrigerator to accurately determine a time period in which the user opens the refrigerator with low frequency. Even if different households that use the refrigerators are active during different time periods a day, the controller predicts door-opening frequency based on the amount of change in number of door-opening times. Thus, the controller can infer the user's living conditions without problems. Specifically, let us assume that a user A gets up and starts to open a refrigerator 1 at 7 am and goes to bed at 10 pm on a day, while a user B gets up and starts to open a refrigerator 1 at 9 pm on a day and goes to bed at 1 pm on the following day. In this case, since the controller determines frequency at which the refrigerator 1 is opened by focusing on the amount of change in number of door-opening times, the controller determines, for example, that a time period in which the user A opens the refrigerator with low frequency is from 0 am to 6 am on the following day and that a time period in which the user B opens the refrigerator with low frequency is from 2 pm to 8 pm.

[0039]

In step S9, the controller 11 executes temperature equalization control, which is described later, as special control in the determined time period with low door-opening frequency.

[0040]

<Special temperature control>

Fig. 9 is a graph illustrating special temperature control according to Embodiment 1 of the present disclosure. The special temperature control is an example of control that the controller executes in a living time period other than the determined time period with low door-opening frequency. In other words, the special control is control designed to prevent start of the special temperature control in the time period with low door-opening frequency.

[0041]

As shown in Fig. 9, the special temperature control is executed first to adjust temperature in the storage compartment 12 to a first set temperature, such as -3

degrees C, that is higher than a temperature for normal temperature control, such as -7 degrees C, during a certain length of time such as 100 minutes by a temperature control unit (not shown) used to adjust temperature in each of the storage compartments 12. The special temperature control is then executed to adjust the temperature in the storage compartment 12 to a second set temperature, such as -11 degrees C, that is lower than the temperature for normal temperature control, such as -7 degrees C, during a certain length of time such as 120 minutes. In this way, the special temperature control is designed to change the temperature in the storage compartment 12 to two different temperatures over two or more unit-time lengths. By such special temperature control, food undergoes supercooling and is frozen.

[0042]

The normal temperature, the first set temperature, and the second set temperature are in a refrigeration temperature range lower than or equal to 0 degrees C. The first set temperature is higher than a normal set temperature such as a mild refrigeration temperature of -7 degrees C and is set in a range between -5 degrees C and 0 degrees C that is higher or equal to a temperature at which food starts freezing. In this example, the first set temperature is -3 degrees C. The second set temperature is set at a temperature lower than the normal temperature and is -11 degrees C in this example.

[0043]

The control execution time lengths and the set temperatures described herein are preferable values selected to allow the controller to enter supercooling control with high accuracy. However, the values may be changed to suit a cooling capacity of the refrigerator 1 or other conditions. The controller redoes the special temperature control in response to door opening and closing. This allows the special temperature control to start at a time when food is loaded in conjunction with door opening and closing.

[0044]

When the refrigerator 1 starts operating, the normal temperature control is executed. When the drawer of the freezer compartment 123 of the storage

compartments 12 is opened and closed in a living time period, the special temperature control is executed in response to opening and closing of the drawer of the freezer compartment 123 in the living time period other than the determined time period with low door-opening frequency. After the special temperature control is finished, the normal temperature control is again executed.

[0045]

Fig. 10 is a flowchart illustrating the special temperature control according to Embodiment 1 of the present disclosure. As shown in Fig. 10, the special temperature control starts in a living time period other than the time period that is determined as a time period with low door-opening frequency.

[0046]

In step S91, when the drawer of the freezer compartment 123 is opened and closed in the living time period other than the determined time period with low door-opening frequency, the controller 11 cools the freezer compartment to a first set temperature of -3 degrees C to maintain the freezer compartment at the first set temperature different from a normal temperature of -7 degrees C for a certain length of time such as 100 minutes.

[0047]

In step S92, the controller 11 determines whether or not the drawer is opened and closed while the freezer compartment is cooled to the first set temperature. When the drawer is opened and closed, the controller returns to step S91 to redo the special temperature control from start. Redoing of the special temperature control will be described later. When the special temperature control is redone, the controller stores for what amount of time the freezer compartment has been maintained at the first set temperature. When the drawer is not opened and closed, the controller transitions to step S93.

[0048]

In step S93, the controller 11 determines whether or not the certain length of time such as 100 minutes has elapsed. When the certain length of time has

elapsed, the controller transitions to step S94. When the certain length of time has not elapsed, the controller returns to step S92.

[0049]

In step S94, the controller 11 cools the freezer compartment to a second set temperature of -11 degrees C to maintain the freezer compartment at the second set temperature different from a normal temperature of -7 degrees C for a certain length of time such as 120 minutes continuously from the state at the first set temperature.

[0050]

In step S95, the controller 11 determines whether or not the drawer is opened and closed while the freezer compartment is cooled to the second set temperature. When the drawer is opened and closed, the controller returns to step S91 to redo the special temperature control from start. When the special temperature control is redone, the controller stores for what amount of time the freezer compartment has been maintained at the first set temperature and the second set temperature. When the drawer is not opened and closed, the controller transitions to step S96.

[0051]

In step S96, the controller 11 determines whether or not the certain length of time such as 120 minutes has elapsed. When the certain length of time has elapsed, the controller transitions to step S97. When the certain length of time has not elapsed, the controller returns to step S95.

[0052]

In step S97, the controller 11 determines whether or not a redo of the special temperature control exists. When a redo exists, the controller transitions to step S98. In step S98, the controller executes the temperature equalization control described later in a next time period that is determined as a time period with low door-opening frequency. When no redo exists, the controller finishes the special temperature control and transitions to the normal temperature control.

[0053]

<Redoing special temperature control>

Fig. 11 is a graph illustrating redoing of special temperature control according to Embodiment 1 of the present disclosure. As shown in Fig. 11, when the door opening-closing detector 13 detects opening and closing of the drawer of the freezer compartment 123 during special temperature control, the controller redoes the special temperature control from start. The redone special temperature control extends into the 6-hours period determined as a time period with low door-opening frequency.

[0054]

In other words, when the drawer is opened and closed again after a period of 50 minutes, for example, following the start of special temperature control, the controller redoes the special temperature control from start. The controller again cools the storage compartment 12 to maintain the storage compartment at the first set temperature for the certain length of time and then maintain the storage compartment at the second set temperature for the certain length of time.

[0055]

<Temperature equalization control>

Fig. 12 is a graph illustrating temperature equalization control according to Embodiment 1 of the present disclosure. As shown in Fig. 12, when the special temperature control is redone one time or more, the temperature in the freezer compartment 123, which is a storage compartment 12, differs from the normal temperature. Hence, the controller executes the temperature equalization control to maintain the temperature in the freezer compartment 123, a storage compartment 12, in a range of temperatures lower than the normal temperature such that a 1-day average temperature in the freezer compartment 123, a storage compartment 12, is similar to the normal temperature. The temperature equalization control is executed in the 6-hours period determined as a time period with low door-opening frequency. The temperature equalization control is equivalent to special control.

[0056]

Since the special temperature control is executed at a plurality of times in a living time period other than the determined time period with low door-opening frequency, the special temperature control is repeated. As a result, the temperature

in the freezer compartment 123, a storage compartment 12, is maintained at the first set temperature higher than the normal temperature. In this case, the controller calculates an average temperature during the living time period for a day, and when the average temperature is higher than the normal temperature, the temperature equalization control is executed in a next time period with low door-opening frequency to cool the freezer compartment to the second set temperature lower than the normal temperature such that the average temperature for the day is identical to the normal temperature. When the refrigerator transitions to a time zone outside the time period with low door-opening frequency after execution of the temperature equalization control, the controller changes the set temperature to the normal temperature. This, even when the special temperature control is executed at a plurality of times a day, enables the controller to maintain the temperature in the freezer compartment 123, a storage compartment 12, at a temperature identical to the normal temperature. This enables the refrigerator to steadily maintain a food preservation period traceable to preservation temperature.

[0057]

As shown in Fig. 12, the special temperature control is executed at a plurality of times in the living time period and the temperature equalization control is executed in the next time period with low door-opening frequency. When the special temperature control is repeated in the living time period, the average temperature for the day is the normal temperature. This requires the temperature equalization control to be executed to keep the storage compartment at the second set temperature in the next period with low door-opening frequency.

[0058]

<Method of calculating temperature equalization control time>

In any time zone where the freezer compartment is at the first set temperature in a living time period, in response to opening and closing of the drawer again in a period in which the first set temperature is selected, the special temperature control is redone from start. An amount of elapsed time from a point of time at which the special temperature control starts before being redone to a point of time at which the

redone special temperature control starts is defined as an extended time. When the special temperature control is executed at a plurality of times and is redone at a plurality of times in the living time period, any extended time is added up.

[0059]

5 The extended time is reset at a time, for example, when the period sifts from the living time period to the time period with low door-opening frequency or when the period shifts from the time period with low door-opening frequency to the living time period.

[0060]

10 In response to opening and closing of the drawer again in a period in which the second set temperature is selected, the special temperature control is redone from start. An amount of time remaining after subtraction of time for which the freezer compartment is actually at the second set temperature by the special temperature control before being redone from time for which the freezer compartment is originally scheduled to be at the second set temperature is defined as an absent time. When
15 the special temperature control is executed at a plurality of times and is redone in a period in which the second set temperature is selected at a plurality of times in the living time period, any absent time is added up.

[0061]

20 The absent time is reset at a time, for example, when the period sifts from the living time period to the time period with low door-opening frequency or when the period shifts from the time period with low door-opening frequency to the living time period.

[0062]

25 A method of calculating time for which temperature equalization control is executed in a next time period with low door-opening frequency based on the extended time and the absent time will be described.

[0063]

30 First, an area determined by multiplying a difference between the first set temperature and a reference temperature by the extended time is defined as A1.

Next, an area determined by multiplying a difference between the reference temperature and the second set temperature by the absent time is defined as A2.
[0064]

Regarding a length of time for which the freezer compartment is at the second set temperature in the next time period with low door-opening frequency, an area determined by multiplying the difference between the reference temperature and the second set temperature by time X for which the temperature equalization control is executed, i.e., the length of time for which the freezer compartment is at the second set temperature, is defined as B.

[0065]

With regard to A1, A2, and B acquired by these calculations, the time X for which the temperature equalization control is executed is determined such that the sum of A1 and A2 is equal to B. According to the method of calculation described above, the time X for which the temperature equalization control is executed in Fig. 12 is calculated. First, the difference between the first set temperature and the reference temperature is a difference between -3 degrees C and -7 degrees C and thus is 4 degrees Kelvin. The difference between the reference temperature and the second set temperature is a difference between -7 degrees C and -11 degrees C and thus is 4 degrees Kelvin. In other words, a relationship among A1, A2, and B in this example can be determined only by operating time. Accordingly, A1 is 50 minutes and thus is 50, A2 is two pieces of 115 minutes and thus is 230, and B is $50 + 230 = 280$. Hence, according to the method of calculation described above, the time X for which the temperature equalization control is executed is 280 minutes, i.e., 4 hours and 40 minutes.

[0066]

In Embodiment 1, the 6-hours period with low door-opening frequency is calculated to enable temperature equalization control in relation to special temperature control. In Embodiment 1, the temperature equalization control is designed to cool the freezer compartment at the second set temperature lower than the normal temperature for 4 hours and 40 minutes within the 6-hours period with low

door-opening frequency, which is an example of a small time allowance. However, on condition that a user does not favor the storage compartment 12 in a state of low temperature as a result of having been cooled at the second set temperature when the time period with low door-opening frequency ends, a constraint may be placed to execute the temperature equalization control for only four hours when the calculated control time exceeds, for example, four hours. If cooling the freezer compartment is expected to take, for example, eight hours because of a control specification, the controller may determine an 8-hours period with low door-opening frequency, whereas the controller in Embodiment 1 determines the 6-hours period with low door-opening frequency.

[0067]

<Effects of Embodiment 1>

According to Embodiment 1, the refrigerator 1 includes the storage compartment 12 including a door designed to open and close and being configured to cool and preserve stored items such as food. The refrigerator 1 includes the door opening-closing detector 13 to detect opening and closing of the door of the storage compartment 12. The refrigerator 1 has the storage unit 111 to receive data about opening and closing of the door detected with the door opening-closing detector 13 and store the number of times the door is opened and closed per given unit-time length for a given number of days. The refrigerator 1 includes the controller 11. The controller 11 calculates an average value for the given number of days that is an average of numbers of times the door is opened and closed each given unit-time length for the given number of days from numbers of door opening-closing times stored for every given unit-time lengths in the storage unit 111. The controller 11 calculates a latest-time-lengths total value that is a sum of the average values for the given number of days of the numbers of door opening-closing times for latest time lengths specified from a starting point of each unit-time length for every unit-time length. The controller 11 calculates an immediately following-time-lengths total value that is a sum of the average values for the given number of days of the numbers of door opening-closing times for immediately following time lengths specified from a

starting point of each unit-time length for every unit-time length. The controller 11 determines a sectioned zone of specified time lengths in which the storage compartment 12 is opened and closed with low frequency based on one of or both of the latest-time-lengths total value and the immediately following-time-lengths total value.

[0068]

According to this configuration, the controller can update the average values for the given number of days whenever 24 hours elapse, grasp the number of times the door is opened and closed for every time zone such that the grasped number adapts to changes in the user's living conditions, and predict a time period in which the user opens the refrigerator with low frequency based on the user's living conditions. The time period with low door-opening frequency is predicted by focusing on the amount of change in number of door opening-closing times rather than an absolute value of the number of door opening-closing times. Thus, the controller can accurately predict a given period with low door-opening frequency even if the absolute value of the number of times the door of the refrigerator 1 is opened and closed differs depending on the household and the user's living conditions differ from ordinary living conditions.

[0069]

According to this configuration, the controller can set a substantial time zone with low door-opening frequency. This prevents a controlled task required to be performed over a plurality of hours from being interrupted halfway.

[0070]

According to this configuration, the controller does not specify a threshold used to determine the number of door-opening times being, for example, 10 times or greater as high door-opening frequency. Thus, the door-opening frequency of a user who opens the door at maximum five times or so per unit-time length is not constantly determined as low throughout a day. An operating state of the refrigerator does not change moment by moment when the door-opening frequency changes per unit-time

length. As a result, the energy consumption performance of the refrigerator does not deteriorate.

[0071]

This configuration enables the controller to find a time period made up of a plurality of hours in which the user does not open the refrigerator 1. This contributes to a reduction in cases in which the temperature equalization control, defrosting, or other special control performed during a time zone in which the user does not open the refrigerator 1 cannot be performed throughout a day.

[0072]

According to Embodiment 1, the controller 11, when one minimum of the latest-time-lengths total value is present, sets a start time of one first unit-time length in which the minimum latest-time-lengths total value is calculated, as a reference point and determines that a period between the specified time lengths before the start time of the first unit-time length and the start time of the first unit-time length is a zone in which the storage compartment 12 is opened and closed with low frequency.

[0073]

According to this configuration, the controller can update the average values for the given number of days whenever 24 hours elapse, grasp the number of times the door is opened and closed for every time zone such that the grasped number adapts to changes in the user's living conditions, and calculate a minimum of the latest-time-lengths total values for every unit-time lengths. Thus, the controller can grasp a zone of latest time lengths specified from a starting point of the first unit-time length where the one minimum exists is a time period in which the user opens the refrigerator 1 with low frequency. As a result, the controller can find that the user opens the refrigerator 1 with lowest frequency in a time zone before the first unit-time length and opens the refrigerator 1 with highest frequency in a time zone from the first unit-time length by accurately grasping changes in level of door-opening frequency. Hence, even if the detector detects opening and closing of the door, for example, in a midnight period where the door-opening frequency is generally low, the controller invariably determines the midnight period as a time period with low door-opening

frequency. Consequently, when the temperature equalization control is required to be executed over a plurality of unit-time lengths at midnight, the controller can execute the temperature equalization control in a time period determined as a time period with low door-opening frequency.

5 [0074]

According to Embodiment 1, the controller 11, when a plurality of minimums of the latest-time-lengths total values are present and one maximum of the immediately following-time-lengths total value is present, sets a start time of one second unit-time length in which the maximum immediately following-time-lengths total value is
10 calculated as a reference point and determines that a period between the specified time lengths before the start time of the second unit-time length and the start time of the second unit-time length is a zone in which the storage compartment 12 is opened and closed with low frequency.

[0075]

15 According to this configuration, the controller can calculate immediately following-time-lengths total values as well as latest-time-lengths total values and when a plurality of minimums of the latest-time-lengths total values are present and one maximum of the immediately following-time-lengths total value is present, grasp that a period between the specified time lengths before the start time of the second
20 unit-time length in which the maximum immediately following-time-lengths total value is calculated and the start time of the second unit-time length is a time period with low door-opening frequency. As a result, the controller can find that the user opens the refrigerator 1 with lowest frequency in a time zone before the second unit-time length and opens the refrigerator 1 with highest frequency in a time zone from the second
25 unit-time length by accurately grasping changes in level of door-opening frequency. Hence, even if the detector detects opening and closing of the door, for example, in a midnight period where the door-opening frequency is generally low, the controller invariably determines the midnight period as a time period with low door-opening frequency. Consequently, when the temperature equalization control is required to
30 be executed over a plurality of unit-time lengths at midnight, the controller can

execute the temperature equalization control in a time period determined as a time period with low door-opening frequency.

[0076]

According to Embodiment 1, the controller 11, when a plurality of minimums of the latest-time-lengths total values are present and a plurality of maximums of the immediately following-time-lengths total values are present, sets a start time of one third unit-time length in which the maximum immediately following-time-lengths total value earliest out of the plurality of the maximum immediately following-time-lengths total values is calculated as a reference point and determines that a period between the specified time lengths before the start time of the third unit-time length and the start time of the third unit-time length is a zone in which the storage compartment 12 is opened and closed with low frequency.

[0077]

According to this configuration, the controller can calculate immediately following-time-lengths total values as well as latest-time-lengths total values and when a plurality of minimums of the latest-time-lengths total values are present and a plurality of maximums of the immediately following-time-lengths total values are present, grasp that a period between the specified time lengths before the start time of the third unit-time length in which the maximum immediately following-time-lengths total value earliest and lowest in serial number out of the plurality of the maximum immediately following-time-lengths total values is calculated and the start time of the third unit-time length is a time period with low door-opening frequency. As a result, the controller can find that the user opens the refrigerator 1 with lowest frequency in a time zone before the third unit-time length and opens the refrigerator 1 with highest frequency in a time zone from the third unit-time length by accurately grasping changes in level of door-opening frequency. Hence, even if the detector detects opening and closing of the door, for example, in a midnight period where the door-opening frequency is generally low, the controller invariably determines the midnight period as a time period with low door-opening frequency. Consequently, when the temperature equalization control is required to be executed over a plurality of unit-

time lengths at midnight, the controller can execute the temperature equalization control in a time period determined as a time period with low door-opening frequency.
[0078]

According to Embodiment 1, the controller 11 executes temperature
5 equalization control or other special control during a plurality of successive unit-time lengths in a time period determined as a zone in which the storage compartment 12 is opened and closed with low frequency.

[0079]

According to this configuration, even if the detector detects opening and closing
10 of the door, for example, in a midnight period where the door-opening frequency is generally low, the controller invariably determines the midnight period as a time period with low door-opening frequency. Consequently, when special control such as the temperature equalization control is required to be executed over a plurality of unit-time lengths at midnight, the special control can be executed in a time period
15 determined as a time period with low door-opening frequency without being interrupted by opening and closing of the door at midnight.

[0080]

According to Embodiment 1, the controller 11 executes special temperature
control to maintain temperature in the storage compartment 12 at a first set
20 temperature different from a normal temperature during a certain length of time and afterward at a second set temperature different from the first set temperature during a certain length of time. The special control is designed to prevent start of the special temperature control in a time zone in which the storage compartment 12 is opened and closed with low frequency.

25 [0081]

According to this configuration, when the special temperature control apart
from the special control is assigned for a plurality of unit-time lengths, the special temperature control can be executed in a period other than the determined time period with low door-opening frequency.

30 [0082]

According to Embodiment 1, when the door is opened and closed during the special temperature control, the controller 11 redoes the special temperature control from start.

[0083]

5 The special temperature control needs to be continuously executed to optimally cool stored items such as food. According to this configuration, when the door is opened and closed during the special temperature control, the special temperature control is redone from start. This enables cooling of stored items such as food optimally and with high quality.

10 [0084]

 According to Embodiment 1, when the special temperature control is redone from start, the controller 11 executes temperature equalization control to adjust the temperature in the storage compartment 12 for a day to the normal temperature by keeping the storage compartment 12 at the second set temperature in a next time zone in which the storage compartment 12 is opened and closed with low frequency. The special control is equivalent to the temperature equalization control.

[0085]

 According to this configuration, when the temperature equalization control equivalent to the special control is assigned for a plurality of unit-time lengths, the temperature equalization control can be executed in a time period determined as a time period with low door-opening frequency. The temperature equalization control is executed when the temperature in the storage compartment 12 at present differs from the normal temperature in the storage compartment 12 as a result of redoing of the special temperature control from start. The temperature equalization control equalizes the temperature in the storage compartment 12 with the normal temperature to maintain the storage compartment 12 at an optimum temperature for cooling stored items such as food.

[0086]

 According to Embodiment 1, the controller 11 determines a living time period other than a time zone in which the storage compartment 12 is opened and closed

with low frequency and executes the special temperature control in the living time period.

[0087]

The special temperature control needs to be continuously executed immediately after opening and closing of the door of the storage compartment 12 to optimally cool stored items such as food. According to this configuration, the special temperature control is executed in the living time period, in which the door of the storage compartment 12 is opened and closed. This enables cooling of stored items such as food optimally and with high quality.

[0088]

According to Embodiment 1, the controller 11 redoes the special temperature control from start during a period extending from the living time period into a time zone in which the storage compartment 12 is opened and closed with low frequency.

[0089]

According to this configuration, when the special temperature control cannot be completed within the living time period, the special temperature control extends into a subsequent time period determined as a time period with low door-opening frequency. This enables cooling of stored items such as food optimally and with high quality owing to execution of the special temperature control before the stored items such as food are damaged by long-term storage.

[0090]

Embodiment 2.

In Embodiment 2, the controller performs defrosting as special control in a given period that is determined as a time period with low door-opening frequency in Embodiment 1.

[0091]

The controller starts defrosting in a determined time zone in which a user opens the storage compartment 12 with low frequency. This enables defrosting while a rise in temperature in the storage compartment 12 is inhibited. In

Embodiment 1, with consideration given to the possibility that the time of temperature

equalization control reaches six hours, the controller calculates latest 6-hours total values and immediately following 6-hours total values of 7-days average values to determine a 6-hours period with low door-opening frequency. However, defrosting and control executed before and after defrosting in Embodiment 2 require

5 approximately three hours. Thus, in Embodiment 2, the controller calculates latest 3-hours total values and immediately following 3-hours total values of 7-days average values to determine a 3-hours period with low door-opening frequency.

[0092]

10 In each of Embodiments 1 and 2, the given periods specified for the latest-hours total values, the immediately following-hours total values, and the time zone with low door-opening frequency are preferably a common period. However, the specified given periods may be different periods. Conventionally, defrosting starts, for example, in response to an operating time of a compressor or a refrigerator 1 or in response to a value detected with a temperature detection unit used to detect

15 temperature of a cooling unit 14.

[0093]

Unfortunately, a determined period in which defrosting is scheduled to start may be daytime in which the user opens the refrigerator with high frequency. This case causes temperature in a storage compartment 12 to rise excessively.

20 [0094]

Another case is that defrosting is scheduled to be performed in a period in which the user does not open and close the refrigerator door. This prevents a rise in temperature in the storage compartment 12. However, when defrosting is scheduled to be performed in a time period with zero door opening-closing frequency, a time at which defrosting is necessary does not sometimes coincide with a time period with zero door opening-closing frequency that changes depending on the user. This creates a possibility that defrosting cannot be performed appropriately.

25 [0095]

To address these problems, the controller in Embodiment 2, in common with

30 the controller in Embodiment 1, uses a method of determining a time period with low

door-opening frequency. This enables extraction of a fairly substantial time zone with low door-opening frequency. This, even if opening and closing of the door is detected during the time zone, enables defrosting while the possibility of causing an excessive rise in temperature in the storage compartment 12 is reduced.

5 [0096]

<Effects of Embodiment 2>

According to Embodiment 2, the refrigerator 1 includes the defrosting heater 15 to defrost the cooling unit 14. The special control is equivalent to defrosting of the cooling unit 14 performed by the defrosting heater 15.

10 [0097]

According to this configuration, the controller predicts a time period with low door-opening frequency and is thereby able to extract a fairly substantial time zone with low door-opening frequency. This, even if opening and closing of the door is detected during the time zone with low door-opening frequency, enables defrosting while an excessive rise in temperature in the storage compartment 12 is inhibited.

15 [0098]

Embodiment 3.

The controller in Embodiment 3, based on a given period with low door-opening frequency that is determined in Embodiment 1, specifies morning, daytime, evening, and midnight time periods and controls operation to suit the time periods.

20 [0099]

In Embodiment 3, the controller specifies the given period with low door-opening frequency as a 6-hours period. The controller defines the 6-hours period with low door-opening frequency as a midnight period and determines the midnight period as a period in which the user opens the refrigerator 1 with low frequency and is asleep in general. The controller defines six hours from an end point of the midnight period as a morning period, and similarly defines six hours from an end point of the morning period as a daytime period and a period from an end point of the daytime period to a starting point of the midnight period as an evening period. Why the six

hours are specified is because a possibility that a day is divided into four 6-hours periods as an ordinary living pattern is taken into consideration.

[0100]

Specifically, a description will be given with an example in which a day is divided by one hour unit into 24 blocks from the 0th block to the 23rd block. When six hours from the 18th block to the 23rd block are determined as a time zone with low door-opening frequency in Embodiment 1, the time zone is defined as a midnight period.

[0101]

The time zone with lowest door-opening frequency is generally expected to be a bedtime regardless of the user. Thus, the controller assumes the time zone as a midnight period and subsequently defines a time zone from the 0th block, an end point of the midnight period, to the 5th block, a point of six hours later, as a morning period and a time zone from the 6th block, an end point of the morning period, to the 11th block, a point of six hours later, as a daytime period and similarly defines a time zone from the 12th block to the 17th block as an evening period.

[0102]

As a day is defined as a series of the morning, the daytime, the evening, and the midnight periods in this way, the controller enables the refrigerator 1 to operate with increased cooling capacity from the midnight period in expectation of a rise in temperature in the storage compartment 12 in the morning period, if the user, for example, uses frozen food for a packed lunch with increased frequency, i.e., frequency with which the freezer compartment 124 of the refrigerator 1 is opened and closed is on the rise in the morning period.

[0103]

When the opening and closing of the freezer compartment 124 is not detected in the morning period in actuality, the controller may learn this detected result and may determine whether or not to allow the refrigerator to operate with increased cooling capacity in the midnight period next time with consideration given to the detected result.

[0104]

Similarly, it is possible that the user prepares a water bottle in the morning period using a large amount of manufactured ice. Thus, the refrigerator 1 operates such that the ice-making compartment starts making ice in the midnight period to complete ice making in the morning period.

[0105]

In expectation of a rise in number of times a drink is taken out in the daytime period, in which the atmospheric temperature rises to a highest point on a day, the refrigerator 1 operates such that cooling performance of the refrigerator compartment 121 increases one hour or a given period before the end point of the morning period. When the opening and closing of the ice-making compartment 122 is not detected in the daytime period in actuality after operation, the controller may learn this detected result and may determine whether or not to allow the refrigerator to cool the compartment in preparation for ice making in the morning period next time with consideration given to the detected result.

[0106]

In expectation that the user who goes shopping in the daytime period opens and closes the storage compartments 12 of the refrigerator 1 after coming back from shopping, the refrigerator 1 may operate with improved cooling performance such that the storage compartments remain in a range of temperatures lower than a temperature set in advance. When the temperature throughout the daytime period is lower than the set temperature by 1 degree C or a given degree at the end point of the daytime period, the controller may learn this result and may determine whether or not to allow the refrigerator to operate with improved cooling performance in expectation of shopping in the daytime period next time.

[0107]

When the controller determines that the user finishes preparing dinner and clearing the table and enters a time for amusement and preparation in a second half of the evening time before going to bed, the refrigerator 1 may operate such that cooling capacity of the storage compartments 12 is lowered during this period. This

helps improve energy-saving performance. When the opening and closing of the door of any of the storage compartments 12 is detected at five times or any given number of times per one hour during this period, the controller may learn this result and may determine whether or not to allow the refrigerator to operate with lowered cooling capacity in the second half of the evening time.

[0108]

In Embodiment 3, the morning, the daytime, the evening, and the midnight periods are defined. However, a day may be divided into a plurality of time periods represented by general symbols like A, B, C, and D.

[0109]

In Embodiment 3 described above, the controller defines a time period with low door-opening frequency as the midnight period, defines the morning, the daytime, and the evening periods subsequent to the midnight period, and sets these periods as a basis to predict the user's living conditions. This enables the refrigerator 1 to optimally operate based on information predicted for every time period in advance.

[0110]

Next, a description will be given of a controller configured to determine whether or not to execute special temperature control suitable for a living pattern of a day such as a holiday even if the door opens and closes in a time period on the day that is different from a time period in which the door opens and closes on days of a usual living pattern.

[0111]

When the special temperature control is executed, the storage unit 111 stores history data about the special temperature control for every four 6-hours periods into which a day is divided, such as the morning, the daytime, the evening, and the midnight periods defined as above or every time periods represented by general symbols like A, B, C, and D. When the special temperature control is executed one or more times in each of the morning, the daytime, and the evening periods of the four periods, the controller determines that an activity is present in the every three time periods from the morning to the evening and controls the refrigerator to prevent

the special temperature control from being executed in the midnight period with low door-opening frequency because of low likelihood of the door opening and closing even if the opening and closing of the door is detected in the midnight period.

[0112]

5 Meanwhile, when the special temperature control is not executed at all in at least one of the morning, the daytime, and the evening periods on a day, the controller determines that no activity is present in at least one time period from the morning to the evening on the day and it is possible for the door to open and close even in the midnight period, which is usually determined as a time period with low door-opening frequency. When the opening and closing of the door is actually
10 detected in the midnight period, the special temperature control is executed.

[0113]

 In this way, even when the living pattern is different from the usual pattern, the controller automatically determines a time at which the special temperature control is
15 executed based on results of predicted door-opening frequency and history data about the special temperature control and thereby executes the special temperature control. This enables the refrigerator to provide optimum temperature control at a suitable time without manual operation by the user.

[0114]

20 <Effects of Embodiment 3>

 According to Embodiment 3, the special control provides operation with a cooling capacity different from the cooling capacity during normal operation.

[0115]

 According to this configuration, in a time period with low door-opening
25 frequency, the refrigerator 1 can operate with a cooling capacity different from the cooling capacity during normal operation. This enables preservation of stored items such as food in the storage compartment 12 optimally and with high quality.

[0116]

 According to Embodiment 3, the controller 11 defines a time zone in which the
30 storage compartment 12 is opened and closed with low frequency as a midnight

period of six hours and determines every six hours from the end point of the midnight period as morning, daytime, and evening periods in sequence. The controller 11 controls the refrigerator with a predetermined cooling capacity suitable for each of the midnight, the morning, the daytime, and the evening periods.

[0117]

According to this configuration, the controller defines a time period with low door-opening frequency as the midnight period and defines time periods subsequent to the midnight period as the morning, the daytime, and the evening periods in sequence. Thus, a day can be divided into sections that are set as a basis to predict the user's living conditions. This enables the refrigerator 1 to optimally operate based on information predicted for each of the midnight, the morning, the daytime, and the evening periods in advance.

[0118]

Embodiments 1 to 3 of the present disclosure may be combined or may each be applied to a part of another embodiment.

Reference Signs List

[0119]

1	refrigerator	11	controller	12	storage compartment	13
	door opening-closing detector	14	cooling unit	15	defrosting heater	111
	storage unit	121	refrigerator compartment	122	ice-making compartment	123
	freezer compartment	124	freezer compartment	125	vegetable	
	compartment	131	door switch	132	drawer switch	133
					drawer switch	

CLAIMS

[Claim 1]

A refrigerator comprising:

5 a storage compartment including a door designed to open and close and being configured to cool and preserve stored items;

a door opening-closing detector to detect opening and closing of the door of the storage compartment;

10 a storage unit to receive data about opening and closing of the door detected with the door opening-closing detector and store a number of times the door is opened and closed per given unit-time length for a given number of days; and

a controller,

15 wherein the controller calculates an average value for the given number of days that is an average of numbers of times the door is opened and closed each given unit-time length for the given number of days from numbers of door opening-closing times stored for every given unit-time lengths in the storage unit,

the controller calculates a latest-time-lengths total value that is a sum of the average values for the given number of days of the numbers of door opening-closing times for latest time lengths specified from a starting point of each unit-time length for every unit-time length,

20 the controller calculates an immediately following-time-lengths total value that is a sum of the average values for the given number of days of the numbers of door opening-closing times for immediately following time lengths specified from a starting point of each unit-time length for every unit-time length, and

25 the controller determines a sectioned zone of specified time lengths in which the storage compartment is opened and closed with low frequency based on one of or both of the latest-time-lengths total value and the immediately following-time-lengths total value.

[Claim 2]

30 The refrigerator of claim 1, wherein the controller, when one minimum of the latest-time-lengths total value is present, sets a start time of one first unit-time length in

which the minimum latest-time-lengths total value is calculated, as a reference point and determines that a period between the specified time lengths before the start time of the first unit-time length and the start time of the first unit-time length is a zone in which the storage compartment is opened and closed with low frequency.

5 [Claim 3]

The refrigerator of either of claim 1 or 2, wherein the controller, when a plurality of minimums of the latest-time-lengths total values are present and one maximum of the immediately following-time-lengths total value is present, sets a start time of one second unit-time length in which the maximum immediately following-time-lengths total value is
10 calculated as a reference point and determines that a period between the specified time lengths before the start time of the second unit-time length and the start time of the second unit-time length is a zone in which the storage compartment is opened and closed with low frequency.

[Claim 4]

15 The refrigerator of any one of claims 1 to 3, wherein the controller, when a plurality of minimums of the latest-time-lengths total values are present and a plurality of maximums of the immediately following-time-lengths total values are present, sets a start time of one third unit-time length in which the maximum immediately following-time-lengths total value earliest out of the plurality of the maximum immediately
20 following-time-lengths total values is calculated as a reference point and determines that a period between the specified time lengths before the start time of the third unit-time length and the start time of the third unit-time length is a zone in which the storage compartment is opened and closed with low frequency.

[Claim 5]

25 The refrigerator of any one of claims 1 to 4, wherein the controller executes special control during a plurality of successive unit-time lengths in a time period determined as a zone in which the storage compartment is opened and closed with low frequency.

[Claim 6]

30 The refrigerator of claim 5, wherein the controller executes special temperature

control to maintain temperature in the storage compartment at a first set temperature different from a normal temperature during a certain length of time and afterward at a second set temperature different from the first set temperature during a certain length of time, and

5 wherein the special control is designed to prevent start of the special temperature control in a time zone in which the storage compartment is opened and closed with low frequency.

[Claim 7]

10 The refrigerator of claim 6, wherein when the door is opened and closed during the special temperature control, the controller redoes the special temperature control from start.

[Claim 8]

15 The refrigerator of claim 7, wherein when the special temperature control is redone from start, the controller executes temperature equalization control to adjust the temperature in the storage compartment for a day to the normal temperature by keeping the storage compartment at the second set temperature in a next time zone in which the storage compartment is opened and closed with low frequency, and

 wherein the special control is equivalent to the temperature equalization control.

[Claim 9]

20 The refrigerator of any one of claims 6 to 8, wherein the controller determines a living time period other than a time zone in which the storage compartment is opened and closed with low frequency and executes the special temperature control in the living time period.

[Claim 10]

25 The refrigerator of claim 9, wherein the controller redoes the special temperature control from start during a period extending from the living time period into a time zone in which the storage compartment is opened and closed with low frequency.

[Claim 11]

30 The refrigerator of claim 5, comprising a defrosting heater to defrost a cooling unit,

wherein the special control is equivalent to defrosting of the cooling unit performed by the defrosting heater.

[Claim 12]

5 The refrigerator of claim 5, wherein the special control provides operation with a cooling capacity different from a cooling capacity during normal operation.

[Claim 13]

10 The refrigerator of any one of claims 1 to 12, wherein the controller defines a time zone in which the storage compartment is opened and closed with low frequency as a midnight period of six hours and determines every six hours from an end point of the midnight period as morning, daytime, and evening periods in sequence, and

the controller controls the refrigerator with a predetermined cooling capacity suitable for each of the midnight, the morning, the daytime, and the evening periods.