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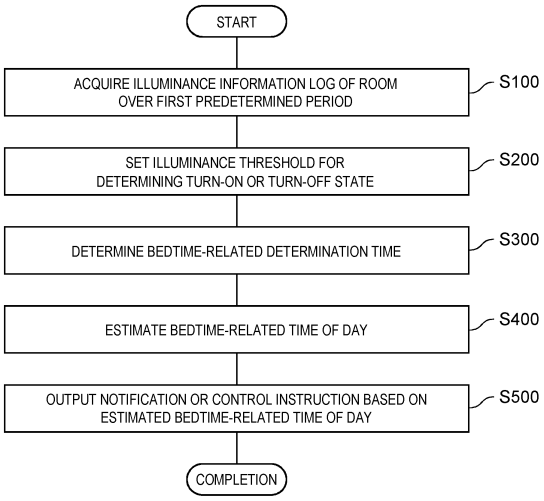
(54) METHOD AND DEVICE FOR ESTIMATING BEDTIME-RELATED TIME OF DAY OF USER OF AIR CONDITIONER

(57) A device for estimating a bedtime-related time of day of a user of an air conditioner is configured to acquire an illuminance information log of a room as an air-conditioning control target of the air conditioner over a past first predetermined period, estimate a bedtime-related time of day related to sleeping of the user in the room based on the illuminance information log, and output, to an information terminal, the bedtime-related time of day and notification information related to an operation of the air conditioner. In addition, the device may also be configured to output, to the air conditioner, control instructions for the air conditioner to operate based on the bedtime-related time of day.

FIG. 1A



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a method and a device for estimating a bedtime-related time of day of a user of an air conditioner.

BACKGROUND ART

[0002] In the related art, a behavior analysis device that analyzes a life behavior of a user is known as described in PTL 1. The behavior analysis device analyzes the life behavior of the user based on learning behavior record data generated by being recorded by the user. The behavior analysis device provides, to the user, content such as an advertisement corresponding to a life style of the user based on the analysis result.

Citation List

Patent Literature

[0003] PTL 1: Japanese Patent No. 6338984

SUMMARY OF THE INVENTION

[0004] In order to analyze the life behavior of the user, the behavior analysis device of the related art performs supervised learning on an estimation condition of the life behavior across a plurality of time zones by using, as teaching data, the learning behavior record data generated by being recorded by the user. However, in order to accurately estimate the life behavior at a finer time granularity, since it is necessary to input a finer behavior record, a user load increases. In addition, based on the analyzed life behavior, the user does not operate a specific home electric appliance, for example, does not use the home electric appliance in relation to an operation of the air conditioner.

[0005] An object of the present disclosure is to provide a method and a device for automatically estimating a bedtime-related time of day of a user of an air conditioner.

[0006] A method for estimating a bedtime-related time of day of a user of an air conditioner according to one aspect of the present disclosure includes acquiring an illuminance information log of a room as an air-conditioning control target of the air conditioner over a past first predetermined period, estimating a bedtime-related time of day related to sleeping of the user in the room based on the illuminance information log, and outputting, to an information terminal, the bedtime-related time of day and notification information related to an operation of the air conditioner.

[0007] A method for estimating a bedtime-related time of day of a user of an air conditioner according to another aspect of the present disclosure includes acquiring an illuminance information log of a room as an air-conditioning control target of the air conditioner over a past first predetermined period, estimating a bedtime-related time of day related to sleeping of the user in the room based on the illuminance information log, and outputting, to the air conditioner, control instructions for the air conditioner to operate based on the bedtime-related time of day.

[0008] A device for estimating a bedtime-related time of day of a user of an air conditioner according to still another aspect of the present disclosure is configured to acquire an illuminance information log of a room as an air-conditioning control target of the air conditioner over a past first predetermined period, estimate a bedtime-related time of day related to sleeping of the user in the room based on the illuminance information log, and output, to an information terminal, the bedtime-related time of day and notification information related to an operation of the air conditioner.

[0009] A device for estimating a bedtime-related time of day of a user of an air conditioner according to still another aspect of the present disclosure is configured to acquire an illuminance information log of a room as an air-conditioning control target of the air conditioner over a past first predetermined period, estimate a bedtime-related time of day related to sleeping of the user in the room based on the illuminance information log, and output, to the air conditioner, control instructions for the air conditioner to operate based on the bedtime-related time of day.

[0010] In the present disclosure, according to the method and the device for estimating a bedtime-related time of day of a user of an air conditioner, the bedtime-related time of day can be automatically estimated based on the illuminance information log. In addition, according to the estimation method and device, it is possible to output the notification or the control instruction related to the operation of the air conditioner based on the estimation result.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1A is a flowchart illustrating an overall example of a method for estimating a bedtime-related time of day according to the present disclosure.

Fig. 1B is a schematic diagram illustrating the overall example of the method for estimating the bedtime-related time of day according to the present disclosure.

Fig. 1C is a schematic diagram illustrating an example of a bedtime-related time of day according to the present disclosure.

Fig. 2 is a block diagram illustrating an example of a schematic configuration related to an air conditioner according to the present disclosure.

Fig. 3 is a flowchart illustrating an example of a method for estimating a bedtime-related time of day associated with according to a first exemplary embodiment.

Fig. 4A is an example of a user interface for notification setting according to the first exemplary embodiment.

Fig. 4B is an example of a user interface for PUSH notification according to the first exemplary embodiment.

Fig. 5 is an example of a notification user interface according to the first exemplary embodiment.

Fig. 6 is a flowchart illustrating an example of a method for estimating a bedtime-related time of day according to a second exemplary embodiment.

Fig. 7 is a flowchart illustrating an example of step S200 (setting process) according to a fourth exemplary embodiment.

Fig. 8 is a schematic diagram illustrating an example of a first illuminance threshold according to the fourth exemplary embodiment.

Fig. 9 is a schematic diagram illustrating an example of a second illuminance threshold according to the fourth exemplary embodiment.

Fig. 10 is a schematic diagram illustrating an example of an illuminance increase threshold according to the fourth exemplary embodiment.

Fig. 11 is a flowchart illustrating an example of step S300 (determination process) according to the fourth exemplary embodiment.

Fig. 12 is a flowchart illustrating an example of step S330 according to the fourth exemplary embodiment.

Fig. 13A is a flowchart illustrating an example of the determination process according to the fourth exemplary embodiment.

Fig. 13B is a flowchart illustrating an example of the determination process according to the fourth exemplary embodiment.

Fig. 14A is a schematic diagram illustrating an example of label creation according to the fourth exemplary embodiment.

Fig. 14B is a schematic diagram illustrating an example of pairing according to the fourth exemplary embodiment.

Fig. 14C is a schematic diagram illustrating an example of pairing according to the fourth exemplary embodiment.

Fig. 14D is a schematic diagram illustrating an example of a bedtime-related determination time according to the fourth exemplary embodiment.

Fig. 15 is a flowchart illustrating an example of step S400 (estimation process) according to the fourth exemplary embodiment.

Fig. 16 is a flowchart illustrating an example of step S430 according to the fourth exemplary embodiment.

Fig. 17 is a flowchart illustrating an example of the estimation process according to the fourth exemplary embodiment.

Fig. 18A is a flowchart illustrating an example of estimation based on an overall median in the fourth exemplary embodiment.

Fig. 18B is a flowchart illustrating an example of estimation based on a day-of-week median in the fourth exemplary embodiment.

Fig. 19A is a schematic diagram illustrating an example of error calculation based on an overall median in the fourth exemplary embodiment.

Fig. 19B is a schematic diagram illustrating an example of error calculation based on a day-of-week median in the fourth exemplary embodiment.

DESCRIPTION OF EMBODIMENT

[0012] First, various aspects of a method and a device for estimating a bedtime-related time of day of a user of an air conditioner will be described.

[0013] A method for estimating a bedtime-related time of day of a user of an air conditioner according to a first aspect of the present disclosure includes acquiring an illuminance information log of a room as an air-conditioning control target of the air conditioner over a past first predetermined period, estimating a bedtime-related time of day related to sleeping of the user in the room based on the illuminance information log, and outputting, to an information terminal, the bedtime-related time of day and notification information related to an operation of the air conditioner.

[0014] In the first aspect, in a method for estimating a bedtime-related time of day of a user of an air conditioner according to a second aspect of the present disclosure, the bedtime-related time of day may include a last entry estimated time when the user finally enters the room before sleeping. In the outputting, the last entry estimated time and the notification information may be output to the information terminal at a time before a first predetermined time period from the last entry estimated time.

[0015] A method for estimating a bedtime-related time of day of a user of an air conditioner according to a third aspect of the present disclosure includes acquiring an illuminance information log of a room as an air-conditioning control target of the air conditioner over a past first predetermined period, estimating a bedtime-related time of day related to sleeping of the user in the room based on the illuminance information log, and outputting, to the air conditioner, control instructions for the air conditioner to operate based on the bedtime-related time of day.

[0016] In the third aspect, in a method for estimating a bedtime-related time of day of a user of an air conditioner according to a fourth aspect of the present disclosure, the bedtime-related time of day may include a last entry estimated time when the user finally enters the room before sleeping. In the outputting, the control instruction to activate the air conditioner may be output to the air conditioner at a time before a first predetermined time period from the last entry estimated time.

[0017] In the third aspect, in a method for estimating a bedtime-related time of day of a user of an air conditioner according to a fifth aspect of the present disclosure, the

bedtime-related time of day may include a start-to-sleep estimated time when the user finally turns off light in the room before sleeping. In the outputting, when a second predetermined time elapses from the start-to-sleep estimated time, in a case where it is determined that the air conditioner is operating, the control instruction to switch the air conditioner to a sleep-related mode may be output to the air conditioner.

[0018] In any one of the first to fifth aspects, in a method for estimating a bedtime-related time of day of a user of an air conditioner according to a sixth aspect of the present disclosure, the illuminance information log may include time-series log data of illuminance values of the room. The method for estimating a bedtime-related time of day may further include setting a first illuminance threshold for determining whether or not the room is in a turn-off state based on the number of data items corresponding to illuminance values over a first time zone related to a sleep time in the illuminance information log within the first predetermined period, and setting a second illuminance threshold for determining whether or not the room is in a turn-on state based on increased illuminance values when illuminance values increase over a second time zone related to before sleeping in the illuminance information log within the first predetermined period.

[0019] In any one of the first to sixth aspects, a method for estimating a bedtime-related time of day of a user of an air conditioner according to a seventh aspect of the present disclosure may further include acquiring a first illuminance threshold and a second illuminance threshold set based on the illuminance information log within the first predetermined period, determining at least one of a turn-on time and a turn-off time for the illuminance information log in a third time zone related to nighttime within a past second predetermined period by using the first illuminance threshold and the second illuminance threshold, and determining at least one of a last entry determination time and a start-to-sleep determination time in the third time zone within the second predetermined period based on the determined turn-on time or turn-off time. In the estimating of the bedtime-related time of day, the bedtime-related time of day may be estimated based on the last entry determination time or the start-to-sleep determination time.

[0020] In the seventh aspect, in a method for estimating a bedtime-related time of day of a user of an air conditioner according to an eighth aspect of the present disclosure, the determining of at least one of the last entry determination time and the start-to-sleep determination time may include creating, as one pair, the determined turn-on time and the determined turn-off time continuous in a time series manner, and setting a turn-on time of a latest pair, among pairs in the third time zone, as the last entry determination time in the third time zone, and a turn-off time of the latest pair as the start-to-sleep determination time in the third time zone.

[0021] In any one of the first to eighth aspects, in a method for estimating a bedtime-related time of day of a user of an air conditioner according to a ninth aspect of the present disclosure, the estimating of the bedtime-related time of day may include acquiring bedtime-related determination times within a portion corresponding to a past third predetermined period, among bedtime-related determination times determined based on the illuminance information log, calculating a median of the acquired bedtime-related determination times, and setting the median of the bedtime-related determination times as the bedtime-related time of day.

[0022] In the ninth aspect, in a method for estimating a bedtime-related time of day of a user of an air conditioner according to a tenth aspect of the present disclosure, in the calculating of the median of the acquired bedtime-related determination times, an overall median and day-of-week medians of the acquired bedtime-related determination times may be calculated. The setting of the median of the bedtime-related determination times as the bedtime-related time of day may include calculating errors between the overall median of the bedtime-related determination times and the determined bedtime-related determination times and errors between day-of-week medians of the bedtime-related times of day and the determined bedtime-related determination times, and setting, as the bedtime-related time of day, the median having a smaller error, of the overall median of the bedtime-related determination times and the day-of-week medians of the bedtime-related times of day.

[0023] A device for estimating a bedtime-related time of day of a user of an air conditioner according to an eleventh aspect of the present disclosure is configured to acquire an illuminance information log of a room as an air-conditioning control target of the air conditioner over a past first predetermined period, estimate a bedtime-related time of day related to sleeping of the user in the room based on the illuminance information log, and output, to an information terminal, the bedtime-related time of day and notification information related to an operation of the air conditioner.

[0024] In the eleventh aspect, in a device for estimating a bedtime-related time of day of a user of an air conditioner according to a twelfth aspect of the present disclosure, the bedtime-related time of day may include a last entry estimated time when the user finally enters the room before sleeping. The device configured to estimate the bedtime-related time of day may be further configured to output, to the information terminal, the last entry estimated time and the notification information at a time before a first predetermined time from the last entry estimated time.

[0025] A device for estimating a bedtime-related time of day of a user of an air conditioner according to a thirteenth aspect of the present disclosure configured to acquire an illuminance information log of a room as an air-conditioning control target of the air conditioner over a past first predetermined period, estimate a bedtime-related time of day related to sleeping of the user in the

room based on the illuminance information log, and output, to the air conditioner, control instructions for the air conditioner to operate based on the bedtime-related time of day.

[0026] In the thirteenth aspect, in a device for estimating a bedtime-related time of day of a user of an air conditioner according to a fourteenth aspect of the present disclosure, the bedtime-related time of day may include a last entry estimated time when the user finally enters the room before sleeping. The device configured to estimate the bedtime-related time of day may be further configured to output, to the air conditioner, the control instruction to activate the air conditioner at a time before a first predetermined time period from the last entry estimated time.

[0027] In the thirteenth aspect, in a device for estimating a bedtime-related time of day of a user of an air conditioner according to a fifteenth aspect of the present disclosure, the bedtime-related time of day may include a start-to-sleep estimated time when the user finally turns off light in the room before sleeping. The device configured to estimate the bedtime-related time of day may be further configured to output, to the air conditioner, the control instruction to switch the air conditioner to a sleep-related mode, in a case where it is determined that the air conditioner is operating, when a second predetermined time elapses from the start-to-sleep estimated time.

[0028] In any one of the eleventh to fifteenth aspects, in a device for estimating a bedtime-related time of day of a user of an air conditioner according to a sixteenth aspect of the present disclosure, the illuminance information log may include time-series log data of illuminance values of the room. The device configured to estimates the bedtime-related time of day may be further configured to set a first illuminance threshold for determining whether or not the room is in a turn-off state based on the number of data items corresponding to illuminance values over a first time zone related to a sleep time in the illuminance information log within the first predetermined period, and set a second illuminance threshold for determining whether or not the room is in a turn-on state based on increased illuminance values when illuminance values increase over a second time zone related to before sleeping in the illuminance information log within the first predetermined period.

[0029] In any one of the eleventh to sixteenth aspects, a device for estimating a bedtime-related time of day of a user of an air conditioner according to a seventeenth aspect of the present disclosure may be further configured to acquire a first illuminance threshold and a second illuminance threshold set based on the illuminance information log within the first predetermined period, determine at least one of a turn-on time and a turn-off time for the illuminance information log in a third time zone related to nighttime within a past second predetermined period by using the first illuminance threshold and the second illuminance threshold, and determine at least one of a last entry determination time and a start-to-sleep determination time in the third time zone within the second predetermined period based on the determined turn-on time or turn-off time. The device configured to estimate the bedtime-related time of day may be further configured to estimate the bedtime-related time of day based on the last entry determination time or the start-to-sleep determination time, when the bedtime-related time of day is estimated.

[0030] In the seventeenth aspect, in a device for estimating a bedtime-related time of day of a user of an air conditioner according to an eighteenth aspect of the present disclosure, when at least one of the last entry determination time and the start-to-sleep determination time is determined, the device configured to estimate the bedtime-related time of day may be further configured to create, as one pair, the determined turn-on time and the determined turn-off time continuous in a time series manner, and set a turn-on time of a latest pair, among pairs in the third time zone, as the last entry determination time in the third time zone, and a turn-off time of the latest pair as the start-to-sleep determination time in the third time zone.

[0031] In any one of the eleventh to eighteenth aspects, in a device for estimating a bedtime-related time of day of a user of an air conditioner according to a nineteenth aspect of the present disclosure, when the bedtime-related time of day is estimated, the device configured to estimate the bedtime-related time of day may be further configured to acquire bedtime-related determination times within a portion corresponding to a past third predetermined period, among bedtime-related determination times determined based on the illuminance information log, calculate a median of the acquired bedtime-related determination times, and set the median of the bedtime-related determination times as the bedtime-related time of day.

[0032] In the nineteenth aspect, in a device for estimating a bedtime-related time of day of a user of an air conditioner according to a twentieth aspect of the present disclosure, when the median of the acquired bedtime-related determination times is calculated, the device configured to estimate the bedtime-related time of day may be further configured to calculate an overall median and day-of-week medians of the acquired bedtime-related determination times. When the median of the bedtime-related determination times is set as the bedtime-related time of day, the device configured to estimate the bedtime-related time of day may be further configured to calculate, errors between the overall median of the bedtime-related determination times and the determined bedtime-related determination times and errors between day-of-week medians of the bedtime-related times of day and the determined bedtime-related determination times, and set, as the bedtime-related time of day, the median having a smaller error, of the overall median of the bedtime-related determination times and the day-of-week medians of the bedtime-related times of day.

[0033] Each of exemplary embodiments to be described below is an example of the present disclosure or an assembly of a plurality of examples. Numerical values, shapes, configurations, steps, and order of the steps, for example, illustrated in each of the following exemplary embodiments are merely examples, and thus are not intended to limit the present disclosure. Components in the following exemplary embodiments includes a component that is not described in an independent claim representing the most superordinate concept, the component being described as an optional component.

[0034] In each of the exemplary embodiments to be described below, modifications may be illustrated for specific elements, and an appropriate combination of any configurations is included for other elements, and each effect is achieved in the combined configuration. In the exemplary embodiments, the configurations of the modifications, the effects of the modifications are obtained.

[0035] In the following detailed description, the terms "first", "second", and the like are only used for description, and should not be understood as explicitly or implying relative importance or a rank of a technical feature. Features limited to "first" and "second" are intended to imply the inclusion of one or more such features.

<<Overall technical concept>>

[0036] Prior to describing specific exemplary embodiments of a method (hereinafter, also referred to as an estimation method) for estimating a bedtime-related time of day of a user of an air conditioner and a device (hereinafter, also referred to as an estimation device) for estimating a bedtime-related time of day of a user of an air conditioner according to the present disclosure, first, a technical concept described in the present disclosure will be described with reference to one example.

[0037] The estimation method and the estimation device of the present disclosure are used to estimate a bedtime-related time of day of a user of an air conditioner. One scenario using the estimation method and the estimation device of the present disclosure is a case where a user usually sleeps in a room where an air conditioner is provided, that is, a room as an air-conditioning control target of an air conditioner at nighttime. The bedtime-related time of day refers to a time related to sleeping of the user in the room. For example, the bedtime-related time of day may include a time when the user enters the room to sleep, a time when the user turns off light in the room to sleep, or a time calculated based on these times.

[0038] The estimation method and the estimation device can estimate the bedtime-related time of day of the user based on illuminance information log of the room in which the user sleeps, and can further output a notification or a control instruction related to an operation of the air conditioner based on the estimation result.

[0039] Fig. 1A is a flowchart illustrating an overall example of an estimation method executed by an estimation device of this example, and Fig. 1B is a schematic diagram illustrating an overall example of an estimation method executed by the estimation device of this example. The estimation device acquires an illuminance information log of a room over a past predetermined period (step S 100). That is, log data corresponding to a first predetermined period is acquired in the illuminance information log of the room. Subsequently, the estimation device sets an illuminance threshold for determining a turn-on state or a turn-off state in the room (step S200, setting process). The estimation device determines a bedtime-related determination time for log data in a specific time zone related to nighttime based on the set illuminance threshold (step S300, determination process). The estimation device estimates a future bedtime-related time of day of the user based on a past bedtime-related determination time (step S400, estimation process). Then, the estimation device outputs notifications or control instructions related to the operation of the air conditioner to an information terminal of the user or the air conditioner based on the estimated bedtime-related time of day (step S500, output process).

[0040] The estimation method of this example includes a learning phase and an execution phase. The learning phase includes the setting process and the determination process, and the trained determination result may be stored in a database. The execution phase includes the estimation process and the output process. In the execution phase, at least a part of the determination result stored in the database is read, and the future bedtime-related time of day is estimated for the user.

[0041] In this example, the bedtime-related time of day includes at least one of a last entry estimated time when the user finally enters the room before sleeping and a start-to-sleep estimated time when the user finally turns off light in the room before sleeping. Fig. 1C is a schematic diagram illustrating an example of the bedtime-related time of day of this example. In the example of Fig. 1C, the illuminance information log includes time-series log data of illuminance values of the room, and the illuminance value is a numerical value detected by an illuminance sensor provided in the room. As illustrated in Fig. 1C, due to the use of the illuminance value, it can be determined whether a lighting device in the room is turned on (turn-on state) or turned off (turn-off state) in a time zone that is an estimation target (that is, the above-described specific time zone related to nighttime). In addition, it can also be determined when the lighting device is turned on (turn-on time) or when the lighting device is turned off (turn-off time).

[0042] The processes are summarized as follows.

[0043] In the setting process, the estimation device sets an illuminance threshold for determining whether the room as the air-conditioning control target is in the turn-on state or the turn-off state based on the illuminance information log of the room.

[0044] In the determination process, the estimation device determines the turn-on time and the turn-off time. The estimation device further determines, as a last entry

determination time, a last turn-on time in the time zone that is the estimation target, and sets, as a start-to-sleep determination time, a last turn-off time in the time zone.

[0045] In the estimation process, the estimation device estimates a future last entry estimated time and a future start-to-sleep estimated time of the user based on a past last entry determination time and a past start-to-sleep determination time.

[0046] In the output process, the estimation device outputs notifications or control instructions related to the operation of the air conditioner based on at least one of the estimated last entry determination time and start-to-sleep determination time.

[0047] Note that, as will be described later, the learning phase and the execution phase can be separately executed. The estimation device may execute only the estimation process and the output process as long as the estimation device can acquire only the determination result stored in advance. In addition, the setting process, the determination process, the estimation process, and the output process do not need to be continuously executed, and can be executed independently of each other. For example, the estimation device can independently execute the determination process as long as the estimation device can acquire only the illuminance information log and a setting result stored in advance in the learning phase. Thus, the estimation method may include only the estimation process and the output process, and may further include at least one of the setting process and the determination process.

«Overall schematic configuration»

[0048] Fig. 2 is a block diagram illustrating an example of a schematic configuration related to the air conditioner according to the present disclosure.

[0049] In the example of Fig. 2, air conditioner 20 includes air-conditioning storage 21, air-conditioning control unit 22, and air-conditioning communication unit 23. Air conditioner 20 may further include at least one temperature sensor 24 to exert functions. Air conditioner 20 may include illuminance sensor 25 for detecting illuminance in the room.

[0050] Air conditioner 20 can be connected to at least one of server 10 and information terminal 30 via air-conditioning communication unit 23. For example, air conditioner 20 may be connected to at least one of server 10 related to air conditioner 20 and information terminal 30 such as a smartphone of the user via the Internet.

[0051] The estimation device according to the present disclosure may be server 10, air-conditioning control unit 22 of air conditioner 20, or information terminal 30. In each of the following examples, although a case where server 10 executes the method of the present disclosure as the estimation device will be mainly described, the present disclosure is not limited thereto. In a case where air-conditioning control unit 22 executes the method of the present disclosure as the estimation device, air conditioner 20 appropriately executes the operation according to the control instruction when the control instruction is received from the estimation device.

[0052] Hereinafter, an outline of each component will be described.

<Air conditioner 20>

[0053] Air conditioner 20 uses, the air-conditioning control target, for example, one room in a house, an apartment, one room in an apartment, or one room for living alone. In particular, a room in which the user usually sleeps at nighttime is the air-conditioning control target. Air conditioner 20 has a cooling function and a heating function, and may further have at least one of a humidification function, a dehumidification function, and an air cleaning function. These functions and operation modes can be freely combined (for example, a cooling dehumidification function, a cooling ventilation mode, and the like).

<Air-conditioning storage 21>

[0054] Air-conditioning storage 21 is a recording medium that records various kinds of information and control programs, and may be a memory that functions as a work area of air-conditioning control unit 22. Air-conditioning storage 21 is achieved by, for example, a flash memory, a random access memory (RAM), a read only memory (ROM), other storage devices, or an appropriate combination thereof.

[0055] In a case where air-conditioning control unit 22 executes the estimation method as the estimation device, air-conditioning storage 21 may store the illuminance information log of the room, or may acquire the illuminance information log from server 10. When the estimation method is executed, air-conditioning control unit 22 may read only necessary log data from the illuminance information log stored in air-conditioning storage 21 or server storage 12.

<Air-conditioning control unit 22>

[0056] Air-conditioning control unit 22 is a controller that controls at least a part of functions of air conditioner 20. Air-conditioning control unit 22 can include a general-purpose processor such as a central processing unit (CPU) that realizes a predetermined function by executing a program, a micro processing unit (MPU), a microcontroller unit (MCU), a field programmable gate array (FPGA), a digital signal processor (DSP), or an application specific integrated circuit (ASIC). Air-conditioning control unit 22 can achieve various kinds of control in air conditioner 20 by calling and executing the control programs stored in air-conditioning storage 21. In addition, air-conditioning control unit 22 can read data or write data stored in air-conditioning storage 21 in cooperation with air-conditioning storage 21.

[0057] Air-conditioning control unit 22 can receive various commands and setting values (for example, an activation command for a specific operation mode and a temperature setting command) from server 10 or information terminal 30 via air-conditioning communication unit 23. Air-conditioning control unit 22 controls each component of air conditioner 20 to exert the cooling function and the heating function of air conditioner 20 based on these setting values and detection values (for example, indoor temperature) received from various sensors (for example, temperature sensor 24). In addition, in a case where air-conditioning control unit 22 executes the estimation method as the estimation device, air-conditioning control unit 22 controls the operation of air conditioner 20 based on the estimation result.

<Air-conditioning communication unit 23>

[0058] Air-conditioning communication unit 23 can also communicate with server 10, information terminal 30 of the user, and the like, and can also transmit and receive, for example, Internet packets. As described above, air-conditioning control unit 22 may cooperate with at least one of server 10 and information terminal 30 via air-conditioning communication unit 23. Air-conditioning communication unit 23 may transmit and receive data by performing communication between server 10, air conditioner 20, and information terminal 30 according to a standard such as Wi-Fi (registered trademark), IEEE802.2, IEEE802.3, 3G, or LTE. In addition to the Internet, air-conditioning communication unit 23 may perform communication by using infrared rays or Bluetooth (registered trademark) such as an intranet, an extranet, a local area network (LAN), an integrated service digital network (ISDN), a value added network (VAN), a cable television (CATV) communication network, a virtual dedicated network, a telephone line network, a mobile communication network, or a satellite communication network.

[0059] Air-conditioning control unit 22 can transmit, to server 10, various kinds of data stored in air-conditioning storage 21, such as detection values by various sensors, operation records of the air conditioner, and control histories, via air-conditioning communication unit 23. Air-conditioning control unit 22 can transmit, to server 10, detection values by various sensors as they are via air-conditioning communication unit 23.

<Temperature sensor 24>

[0060] Temperature sensor 24 may include, for example, an indoor temperature sensor for detecting an indoor temperature of the room and an outdoor temperature sensor for detecting an outside air temperature outside. Information detected by temperature sensor 24 is input to and stored in air-conditioning storage 21, and is then used by air-conditioning control unit 22 or is transmitted to information terminal 30 or server 10.

<Illuminance sensor 25>

[0061] Illuminance sensor 25 is a sensor for detecting illuminance of light received in the room. Illuminance sensor 25 converts light incident on a light receiving element, for example, light from lighting device 40 in the room into a current, and detects ambient brightness. Illuminance sensor 25 may perform detection at regular time intervals, and may store a detected illuminance value and a detection date and time in air-conditioning storage 21. The illuminance value detected by illuminance sensor 25 is input to and stored in air-conditioning storage 21, and is then used by air-conditioning control unit 22 or is transmitted to information terminal 30 or server 10.

[0062] In the configuration example of Fig. 2, illuminance sensor 25 is mounted on air conditioner 20, but the disposition of illuminance sensor 25 is not limited thereto. Illuminance sensor 25 may be mounted not in a body of air conditioner 20 but in another home appliance in the room, or in any location where light from lighting device 40 can be received in the room, or may be an independent sensor device. When the estimation method is executed, the estimation device can acquire information used for estimation from illuminance sensor 25 regardless of the mounting location of illuminance sensor 25. For example, in a case where server 10 executes the estimation method as the estimation device, server 10 may acquire the illuminance value from illuminance sensor 25 via air conditioner 20 or another home appliance, or may acquire the illuminance value directly from illuminance sensor 25. In a case where information terminal 30 executes the estimation method as the estimation device, information terminal 30 may acquire the illuminance value or the illuminance information log from illuminance sensor 25 via server 10, or may directly acquire the illuminance value from illuminance sensor 25 and create the illuminance information log.

[0063] Note that, air conditioner 20 may further include other sensors, for example, a humidity sensor and a user activity amount sensor. These sensors may perform detection at regular time intervals and may store the detected values in air-conditioning storage 21.

information terminal 30>

[0064] Information terminal 30 is an information terminal capable of performing data communication with air conditioner 20. For example, the information terminal may be a smartphone, a portable telephone, a mobile phone, a tablet, a wearable device, a computer, or the like of the user of air conditioner 20 in which dedicated related application 32 is incorporated. In a case where information terminal 30 executes the estimation method as the estimation device, information terminal 30 may acquire the illuminance information log from server 10 or may read the illuminance information log stored therein when the estimation method is executed.

[0065] Server 10 or air-conditioning control unit 22 can

acquire settings or commands input by the user via information terminal 30. Generally, information terminal 30 includes a display for displaying a graphical user interface (GUI). However, in a case where the information terminal interacts with a user via a voice user interface (VUI), information terminal 30 may include a speaker and a microphone instead of or in addition to a display.

[0066] In one example, when the bedtime-related time of day and notification information related to the operation of air conditioner 20 are received from the estimation device, information terminal 30 presents the bedtime-related time of day and the notification information to the user via the UI. In another example, information terminal 30 creates a time for presentation and a notification content for presentation based on the received bedtime-related time of day and notification information, and then presents the time for presentation and the notification content to the user. The time for presentation and the notification content may be different from the received bedtime-related time of day and notification information.

<Lighting device 40>

[0067] Lighting device 40 is installed in the room as the air-conditioning control target of air conditioner 20, and provides a light source to the room. The light source preferably has a certain degree of illuminance, and particularly preferably has illuminance sufficient for reading and daily living operations. Lighting device 40 may be a light bulb (incandescent lamp) fixture, a fluorescent lamp fixture, or a high intensity discharge (HID), for example, from a type of built-in light source. Lighting device 40 may be a pendant, a ceiling, a chandelier, a spotlight, a floor stand, or a table stand, for example, from a mode of installation in the room.

[0068] In one example, lighting device 40 can be connected to at least one of server 10 and information terminal 30 via the Internet or other home appliances. For example, lighting device 40 may transmit at least one of switch-on information and switch-off information of lighting device 40 itself and the amount of light or luminous intensity to be emitted to server 10 via the Internet.

<Server 10>

[0069] Server 10 is a server for managing and controlling the at least one air conditioner 20, but may be used for other purposes. For example, server 10 may be a management server of a manufacturer of air conditioner 20 for managing at least one air conditioner 20 or for collecting data. Alternatively, server 10 may be an application server. Server 10 can be executed as the estimation device of the present disclosure. In the present disclosure, server 10 includes server storage 12 and server control unit 14. Server 10 may further include server communication unit 16 for communicating with air conditioner 20 or information terminal 30.

<Server storage 12>

[0070] Server storage 12 is a recording medium that records various kinds of information and control programs, and may be a memory that functions as a work area of server control unit 14. Server storage 12 is achieved by, for example, a flash memory, a solid state device (SSD), a hard disk, a RAM, a ROM, other storage devices, or an appropriate combination thereof. Server storage 12 may be a memory inside server 10, or may be a storage device connected to server 10 by wireless communication or wired communication.

[0071] Server storage 12 may store, as log data, information received from air conditioner 20 and various sensors. In a case where server 10 executes the estimation method as the estimation device, when the illuminance information is received, server 10 writes the received illuminance information and the detected date and time in the illuminance information log stored in server storage 12. That is, server 10 may write the information received from illuminance sensor 25 or lighting device 40 in the illuminance information log. The illuminance information log may include at least one of the illuminance value detected by illuminance sensor 25, the switch-on information or the switch-off information of lighting device 40, and the amount of light emitted by lighting device 40 at regular time intervals. When the estimation method is executed, server control unit 14 may read as much log data as necessary from the illuminance information log stored in server storage 12.

[0072] Server storage 12 may store information for executing the estimation method. For example, air-conditioning storage 21 may store at least one threshold set (trained) in the setting process, at least one determination condition available in the determination process, a determination result in the determination process, and an estimation result in the estimation process.

[0073] In addition, server storage 12 may store a program for causing the estimation device (for example, server 10) to execute the estimation method.

<Server control unit 14>

[0074] Server control unit 14 of server 10 is a controller that controls entire server 10. Server control unit 14 includes a general-purpose processor such as a CPU, an MPU, a GPU, an FPGA, a DSP, or an ASIC that achieves a predetermined function by executing a program. Server control unit 14 can achieve various kinds of control in server 10 by calling and executing a control program stored in server storage 12. In addition, server control unit 14 can read data and write data stored in server storage 12 in cooperation with server storage 12. Server control unit 14 is not limited to one that achieves a predetermined function by cooperation of hardware and software, and may be a hardware circuit designed exclusively for achieving a predetermined function.

<Server communication unit 16>

[0075] Server communication unit 16 can also transmit and receive Internet packets, that is, communicate with air conditioner 20 and information terminal 30 in cooperation with server control unit 14. For example, server 10 may receive a command from information terminal 30 via server communication unit 16, or may transmit an instruction to air conditioner 20. Server communication unit 16 or air-conditioning communication unit 23 may transmit and receive data by performing communication according to a standard such as Wi-Fi (registered trademark), IEEE802.2, IEEE802.3, 3G, or LTE among server 10, air conditioner 20, and information terminal 30. In addition to the Internet, the server communication unit may perform communication by using infrared rays or Bluetooth (registered trademark) such as an intranet, an extranet, a LAN, ISDN, VAN, a CATV communication network, a virtual dedicated network, a telephone line network, a mobile communication network, or a satellite communication network.

<<First exemplary embodiment>>

<Estimation method for outputting notification information related to operation of air conditioner 20>

[0076] Hereinafter, a first exemplary embodiment of the estimation method and the estimation device according to the present disclosure will be described in detail with reference to the drawings as appropriate. Hereinafter, the estimation method and the estimation device of the present disclosure will be described by using an aspect in which server 10 executes the function as the estimation device, but the present disclosure is not limited thereto. The estimation device (server 10) estimates the bedtime-related time of day and outputs the notification information related to the operation of air conditioner 20 to information terminal 30 based on the estimation result.

[0077] As described above, the bedtime-related time of day refers to a time related to sleeping of the user in the room. For example, the bedtime-related time of day may include at least one of the last entry estimated time when the user finally enters the room before sleeping and the start-to-sleep estimated time when the user finally turns off light in the room before sleeping.

[0078] Fig. 3 is a flowchart illustrating an example of a method for estimating a bedtime-related time of day according to the first exemplary embodiment. The estimation method according to the first exemplary embodiment includes step S 100, step S400A, and step S510. That is, the estimation method according to the first exemplary embodiment does not perform the setting process and the determination process.

[0079] Server control unit 14 acquires the illuminance information log of the room as the air-conditioning control target of air conditioner 20 over the past first predetermined period from server storage 12 (step S100). More specifically, server control unit 14 reads the log data of the illuminance information log corresponding to the first predetermined period out of the illuminance information log from server storage 12.

[0080] The first predetermined period can be determined by the amount of data necessary for sufficiently accurately estimating the bedtime-related time of day. For example, the first predetermined period may be 14 days, 20 days, 28 days, 30 days, 35 days, or 42 days. In addition, as an example, the first predetermined period refers to a first predetermined period immediately before a point in time at which the estimation method is executed, but the present disclosure is not limited thereto.

[0081] In one example, the first predetermined period can be set by an execution frequency of the estimation method. For example, in a case where server control unit 14 estimates the bedtime-related time of day every week and a day-of-week median, a mean absolute error of each day of the week, or the like is applied in the determination process or the estimation process to be described later, the first predetermined period may be a multiple of seven days.

[0082] Then, server control unit 14 estimates the bedtime-related time of day based on the illuminance information log (step S400A). Server control unit 14 reads, from server storage 12, at least a part of the determination results that has already been determined and saved in server storage 12. For example, server control unit 14 may read only portions corresponding to the same first predetermined period among the stored determination results. In addition, server control unit 14 may read a determination result of portions corresponding to another predetermined period different from the first predetermined period.

[0083] In step S400A, server control unit 14 further estimates the bedtime-related time of day based on the illuminance information log acquired in step S 100 and the determination result acquired in step S400A. Step S400A in Fig. 3 and step S400 in Fig. 1A may be completely the same, or the same estimation process may be performed after a determination result necessary for estimation is acquired by different means.

[0084] Note that, a case where the bedtime-related time of day is estimated based on the illuminance information log includes a case where a determination result is acquired based on the illuminance information log and the bedtime-related time of day is estimated based on the determination result. In a case where the bedtime-related time of day can be estimated only by the acquired determination result, a case where step S 100 is performed to acquire the illuminance information log may be omitted.

[0085] In the output process, server control unit 14 outputs the bedtime-related time of day and the notification information related to the operation of air conditioner 20 to information terminal 30 (step S510). For example, "last entry estimated time: 23:00, May 24" or "start-to-sleep estimated time: 23:30, May 24" may be used as an ex-

ample of the bedtime-related time of day that is estimated and output.

[0086] Regarding the notification information, in one example, in the output process, the estimation device (server 10) creates the notification information based on indoor environment information of the room and a current operation status of air conditioner 20. In one example, when it is determined that an indoor environment of the room is not comfortable because air conditioner 20 is not operating at a time before a first predetermined time period from the last entry estimated time, the determination result is used as the notification information. In step S510, server control unit 14 outputs the last entry estimated time and the notification information to information terminal 30 at a time before the first predetermined time period from the last entry estimated time. Such notification information can prompt the user to activate air conditioner 20.

[0087] The determination whether or not the indoor environment is comfortable can be made, for example, by comparing the indoor temperature of the room with a set temperature. In one example, the indoor environment information includes an indoor temperature. Server control unit 14 acquires the indoor temperature of the room and the set temperature of air conditioner 20, and determines that the indoor environment is not comfortable when a difference between the indoor temperature and the set temperature is more than or equal to a predetermined temperature threshold. The set temperature may be a user set temperature input by the user or an internal set temperature at which air conditioner 20 actually operates for air-conditioning control. In one example, the indoor environment information further includes indoor humidity or indoor air quality. Server control unit 14 determines whether or not the indoor environment is comfortable in consideration of other parameters such as a difference between the indoor humidity and a set humidity and a difference between the indoor air quality and a set air quality as the indoor environment information other than the temperature.

[0088] The first predetermined time is a time required to set the indoor environment of the current room to be comfortable. For example, the first predetermined time is a time for lowering the indoor temperature in a cooling operation or a time for raising the indoor temperature in a heating operation. For example, the first predetermined time may be 15 minutes, 30 minutes, 60 minutes, or 90 minutes. In order to enable the indoor environment of the room to be comfortable by a time when the user enters the room to sleep, server control unit 14 determines whether or not the user is comfortable at a time before the first predetermined time period from the last entry estimated time and outputs the notification information.

[0089] When the bedtime-related time of day and the notification information are received from the estimation device, information terminal 30 presents the bedtime-related time of day and the notification information to the user via PUSH notification or the UI of related application 32.

[0090] Fig. 4A is an example of a user interface for notification setting. A notification setting screen is displayed on screen SC1 illustrated in Fig. 4A. A comfortable temperature range set by the user is displayed in display region R1. A date and time when next notification (for example, notification on a current day or a next day) is scheduled is displayed in display region R2. The time displayed here is a time that is before a first predetermined time period from the last entry estimated time. A toggle button for switching between validation and invalidation of a notification function is displayed in display region R3.

[0091] When the notification function is invalidated by the user, server control unit 14 does not output the notification information even though server control unit 14 determines that "the difference between the indoor temperature of the room and the set temperature is more than or equal to the predetermined temperature threshold and the air conditioner is not operating" at a time before the first predetermined time period from the last entry estimated time. Alternatively, in this case, server control unit 14 outputs the notification information to information terminal 30, but information terminal 30 does not present the notification information to the user.

[0092] When the notification function is enabled, server control unit 14 inquires of air conditioner 20 about operation information of air conditioner 20 and the indoor environment information of the room at a time before the first predetermined time period from the last entry estimated time. It is assumed that it is determined that "the difference between the indoor temperature of the room and the set temperature is more than or equal to the predetermined temperature threshold, and the air conditioner is not operating" based on the received operation information and indoor environment information. In this case, server control unit 14 may output the fact that the room is not comfortable as the notification information, and may further include a message prompting the activation of air conditioner 20 in the notification information and may output the notification information.

[0093] Fig. 4B is an example of a user interface of the PUSH notification. On a screen SC2 illustrated in Fig. 4B, a PUSH notification having characters "room before going to bed is outside comfortable temperature range." is displayed in display region R6. When the user clicks this PUSH notification, information terminal 30 may transition a current display screen to another screen on which more detailed information is displayed, or may activate related application 32 (see Fig. 2) to display the detailed information.

[0094] In one example, as will be described later, the estimation device outputs a control instruction to air conditioner 20 based on the start-to-sleep estimated time. Air conditioner 20 controls the operation thereof based on the control instruction, and automatically switches to a sleep mode, for example, at the received start-to-sleep estimated time. Such an automatic switching function

may also be displayed on the screen SC1 illustrated in Fig. 4A. For example, the toggle button for switching between the validation and invalidation of the automatic switching function is displayed in display region R4 of Fig. 4A. A scheduled time for automatic switching, that is, the start-to-sleep estimated time is displayed in display region R5 of Fig. 4A.

[0095] Note that, the estimation process of the estimation method may be performed every day to estimate a bedtime-related time of day on the current day, or may collectively estimate and store bedtime-related times of day on several days in the future (including the current day). For example, server control unit 14 may estimate bedtime-related times of day every day, every three days, every seven days, and every ten days. In a case where bedtime-related times of day are estimated for several days, server control unit 14 may output only the bedtime-related time of day and the notification information for the current day to information terminal 30 in the output process. Alternatively, server control unit 14 may collectively output the estimated bedtime-related times of day to information terminal 30, and may further output the notification information for the current day to information terminal 30.

[0096] In one example, in a case where at least one of the setting process and the determination process is still being trained, the fact that the at least one is being trained is presented to the user via information terminal 30. For example, in a case where an appropriate threshold has not yet been set in the setting process, or in a case where the number of determination results available for estimation has not yet been sufficient, server control unit 14 causes information terminal 30 to present information indicating that the at least one is "being trained". Fig. 5 is an example of a notification user interface according to the first exemplary embodiment. On a screen SC3 of the GUI of information terminal 30 illustrated in Fig. 5, characters "being trained" are displayed in display region R7, but the bedtime-related time of day and the notification information are not displayed.

[0097] In a case where air-conditioning control unit 22 or information terminal 30 executes estimation as the estimation device, the estimation device acquires the illuminance information log from server 10 or air conditioner 20, performs the estimation method, and outputs the bedtime-related time of day or the like to information terminal 30.

[0098] In one example, the estimation device (for example, air-conditioning control unit 22, server 10, or information terminal 30) has a program used to execute the estimation method as described above. The program causes the estimation device to execute the estimation method.

[0099] According to the estimation method and the estimation device of the present disclosure, it is possible to acquire the illuminance information log of the room as the air-conditioning control target and automatically estimate the bedtime-related time of day of the user based on the acquired illuminance information log. Thus, although an input is not required for the estimation device, the last entry estimated time or the start-to-sleep estimated time can be accurately estimated. In addition, according to the estimation method and the estimation device, a notification related to the operation of the air conditioner can be output to the information terminal based on the estimation result, and the user can be prompted to appropriately operate the air conditioner.

«Second exemplary embodiment»

<Estimation method for outputting control instruction based on last entry estimated time>

[0100] In a second exemplary embodiment, the estimation device estimates the bedtime-related time of day, and outputs control instructions for air conditioner 20 to operate based on the estimation result to air conditioner 20. Hereinafter, although the estimation method and the estimation device of the present disclosure will be described by using an aspect in which server 10 executes the estimation method as the estimation device, the present disclosure is not limited thereto.

[0101] First, since the estimation device performs automatic control on air conditioner 20, it is preferable to obtain an agreement of the user in advance. For example, as in display region R4 of the setting screen SC1 illustrated in Fig. 4A, the agreement of the user can be obtained in advance by a toggle button for switching between validation and invalidation of an automatic control function.

[0102] Fig. 6 is a flowchart illustrating an example of a method for estimating a bedtime-related time of day according to the second exemplary embodiment. The estimation method according to the second exemplary embodiment includes step S 100, step S400A, and step S520. That is, in the estimation method according to the second exemplary embodiment, the setting process and the determination process are not performed.

[0103] Server control unit 14 estimates the bedtime-related time of day by executing step S 100 and step S400A similar to the steps in the first exemplary embodiment. There is a difference from the first exemplary embodiment in the output process. In the second exemplary embodiment, server control unit 14 outputs the control instructions for air conditioner 20 to operate based on the bedtime-related time of day to air conditioner 20 (step S520). The bedtime-related time of day according to the second exemplary embodiment includes the last entry estimated time when the user finally enters the room before sleeping.

[0104] In step S520, server control unit 14 may output the control instruction to activate air conditioner 20 to air conditioner 20 at a time before the first predetermined time period from the last entry estimated time. For example, in a case where it is determined that the indoor environment of the room is not comfortable, server control

unit 14 outputs the control instruction to operate air conditioner 20 to set the indoor environment of the room to be comfortable before the bedtime-related time of day comes. More specifically, when it is determined that the difference between the indoor temperature or the indoor humidity of the room and the set temperature or the set humidity is more than or equal to the predetermined threshold and that air conditioner 20 is not operating, server control unit 14 outputs the control instruction.

[0105] The control instruction may include at least one of designation of an operation mode (for example, a cooling mode, a heating mode, or a dehumidifying mode), designation of a set temperature, and designation of a set humidity other than the activation of air conditioner 20. When air-conditioning control unit 22 receives the control instruction from server 10 via air-conditioning communication unit 23, the air-conditioning control of the room is performed according to the control instruction, and the indoor environment of the room is set to be comfortable before the bedtime-related time of day comes.

[0106] In one example, in a case where the agreement of the user is obtained in advance for the automatic control function, server control unit 14 determines whether or not to output the control instruction based on a location of the user. When it is determined that a condition for issuing the control instruction as described above is satisfied, server control unit 14 acquires the location of the user. In a case where it is determined that the location of the user is not within a predetermined range around a location of the room, server control unit 14 does not output the control instruction to air conditioner 20. That is, in a case where it is determined that the user is not in the room or the user is not near the room, server control unit 14 does not automatically activate the operation of air conditioner 20.

[0107] In one example, server control unit 14 attempts to obtain the agreement of the user for the control instruction before outputting the control instruction, regardless of whether or not the agreement of the user has been obtained in advance for the automatic control function. Server control unit 14 displays, to the user, a content of the control instruction such as "activate air conditioner" via related application 32 of information terminal 30, and prompts the user to agree the control instruction. Server control unit 14 outputs the control instruction to air conditioner 20 after receiving the agreement from the user via information terminal 30.

[0108] As a result, processing of estimating the last entry estimated time and outputting the control instruction based on the estimation result is completed. The estimation device can automatically estimate the last entry estimated time based on the acquired illuminance information log, and can automatically control the operation of the air conditioner based on the estimation result. In case where the indoor environment of the room is not comfortable, the estimation device can automatically activate the air conditioner at a time before the first predetermined time period from the last entry estimated time. Thus, the estimation device can appropriately control the air conditioner to set the room to be comfortable before the user finally enters the room to sleep, and can promote good sleep of the user.

<<Third exemplary embodiment>>

<Estimation method for outputting control instruction based on start-to-sleep estimated time>

[0109] As in the second exemplary embodiment, in a third exemplary embodiment, the estimation device estimates the bedtime-related time of day and outputs, to the air conditioner 20, the control instructions for air conditioner 20 to operate based on the estimation result. In the estimation method according to the third exemplary embodiment, the setting process and the determination process are not performed. Hereinafter, although the estimation method and the estimation device of the present disclosure will be described by using an aspect in which server 10 executes the estimation method as the estimation device, the present disclosure is not limited thereto.

[0110] Although the estimation method and the estimation device according to the third exemplary embodiment estimate the bedtime-related time of day by executing step S 100 to step S520 similar to the second exemplary embodiment, contents of the control instructions to be output and timings to be output are different. Note that, as in the second exemplary embodiment, since the estimation device performs the automatic control on air conditioner 20, it is preferable to obtain the agreement of the user in advance.

[0111] The bedtime-related time of day according to the third exemplary embodiment includes the start-to-sleep estimated time when the user finally turns off light in the room before sleeping. In step S520, server control unit 14 may output, to air conditioner 20, the control instruction to switch the operation of air conditioner 20 to a bedtime-related mode when a second predetermined time has elapsed from the start-to-sleep estimated time. The second predetermined time may be, for example, 0 hour, half hour, 1 hour, 2 hours, or 3 hours.

[0112] The bedtime-related mode is one of the operation modes of air conditioner 20 for the purpose of preparing a comfortable sleep environment and promoting good sleep of the user. In the bedtime-related mode, air-conditioning control unit 22 may perform the air-conditioning control according to a sleep activity of the user. For example, in the bedtime-related mode, air-conditioning control unit 22 may perform the air-conditioning control to set the indoor temperature to 26°C to 28°C such that the indoor temperature does not excessively decrease. In addition, in the bedtime-related mode, air-conditioning control unit 22 may control a direction of a blown-out airflow of air conditioner 20 such that the blown-out airflow does not directly hit the user. The bedtime-related mode is also called a sleep mode, a good sleep mode, or the like.

[0113] In one example, server control unit 14 inquires of air conditioner 20 about the operation information when the second predetermined time has elapsed from the start-to-sleep estimated time. When it is determined that air conditioner 20 is operating based on the received operation information, the control instruction to switch the operation mode of air conditioner 20 to the bedtime-related mode is output to air conditioner 20.

[0114] In one example, when the second predetermined time has elapsed from the start-to-sleep estimated time, server control unit 14 determines whether or not to output the control instruction based on the turn-on state or the turn-off state of the room.

[0115] In a case where the second predetermined time has elapsed from the start-to-sleep estimated time but the room is in the turn-on state, the user may not actually sleep yet. Thus, in a case where the second predetermined time has elapsed from the start-to-sleep estimated time and it is determined that the room is in the turn-on state, server control unit 14 does not output the control instruction to switch to the bedtime-related mode, or delays the output thereof. In a case where the output is delayed, server control unit 14 determines the state of the room again after a certain time. Server control unit 14 outputs the control instruction to switch to the bedtime-related mode only in a case where it is determined that the room is turned off.

[0116] In another example, air conditioner 20 includes a human sensor. Server control unit 14 can determine whether or not the user is in the room or takes a sleeping action via the human sensor. In a case where it is determined that the second predetermined time has elapsed from the start-to-sleep estimated time and the user is not in the room, server control unit 14 does not output the control instruction to switch to the bedtime-related mode, or delays the output thereof.

[0117] In order to determine the turn-on state or the turn-off state of the room, server control unit 14 may acquire a latest illuminance value by illuminance sensor 25 and an illuminance threshold for determining whether the room is in the turn-on state or the turn-off state. The illuminance threshold may include, for example, at least one of a first illuminance threshold for determining whether or the room is in the turn-off state and a second illuminance threshold for determining whether or not the room is in the turn-on state, which are set in advance in the setting process. In a case where the acquired latest illuminance value is less than or equal to the first illuminance threshold or the illuminance value is not more than the second illuminance value, it is determined that the room is in the turn-off state. In a case where the acquired latest illuminance value is not less than the first illuminance threshold or the illuminance value is more than or equal to the second illuminance value, it is determined that the room is in the turn-on state.

[0118] In order to determine the turn-on or the turn-off state of the room, server control unit 14 may acquire the switch-on information or the switch-off information of lighting device 40. In this case, server control unit 14 inquires of lighting device 40 about the switch-on information or the switch-off information. In a case where lighting device 40 is switched on, it is determined that the room is in the turn-on state, and in a case where lighting device 40 is switched off, it is determined that the room is in the turn-off state.

[0119] By doing this, the operation of air conditioner 20 can be automatically switched to the bedtime-related mode at a more accurate timing.

[0120] In one example, in step S520, server control unit 14 outputs the control instruction to stop the operation of air conditioner 20 to air conditioner 20 instead of the control instruction to switch air conditioner 20 to the bedtime-related mode. The automatic stopping of the operation is useful for energy saving of air conditioner 20. Note that, in order to perform the automatic control on air conditioner 20, it is preferable to obtain the agreement of the user in advance.

[0121] In order to execute an automatic operation stop function more safely, server control unit 14 determines whether or not to output the control instruction based on the outside air temperature or external information regarding the outside air temperature. Server control unit 14 may acquire an external temperature of the room from an external temperature sensor of air conditioner 20. In addition, a current or future outside air temperature may be acquired from an external information source (for example, a weather information source) connectable to server 10 via the Internet.

[0122] Only when it is determined that the acquired outside air temperature is within a predetermined temperature range, server control unit 14 outputs the control instruction to stop the operation of air conditioner 20 to air conditioner 20. That is, the operation of air conditioner 20 is stopped only when the outside air temperature is neither too hot nor too cold. On the other hand, when it is determined that the second predetermined time has elapsed from the start-to-sleep estimated time and the outside air temperature is outside the predetermined temperature range, server control unit 14 outputs the control instruction to switch air conditioner 20 to the bedtime-related mode.

[0123] As a result, processing of estimating the start-to-sleep estimated time and outputting the control instruction based on the estimation result is completed. The estimation device can automatically estimate the last entry estimated time based on the acquired illuminance information log, and can automatically control the operation of the air conditioner based on the estimation result. The estimation device can automatically switch the operation of the air conditioner to the bedtime-related mode or stop the operation thereof after the start-to-sleep estimated time. Thus, the estimation device can appropriately control the air conditioner and can reduce power consumption while maintaining the indoor environment appropriate for sleep.

<<Fourth exemplary embodiment>>

<Estimation of bedtime-related time of day>

[0124] In a fourth exemplary embodiment, details of the setting process, the determination process, and the estimation process (Fig. 1B) for estimating the bedtime-related time of day of the user in the room as the air-conditioning control will be described. As described in "Overall technical concept", the estimation method may include the learning phase and the execution phase. The learning phase may include the setting process and the determination process, and the trained determination result may be stored in the database. The execution phase may include the estimation process and the output process. The setting process, the determination process, the estimation process, and the output process do not need to be continuously executed, and can be executed independently of each other.

[0125] An outline of each process is once more as follows.

[0126] In the setting process, the estimation device sets an illuminance threshold for determining whether the room as the air-conditioning control target is in the turn-on state or the turn-off state based on the illuminance information log of the room.

[0127] In the determination process, the estimation device determines the turn-on time and the turn-off time for the log data of the illuminance information log. The estimation device further determines, as the last entry determination time, the last turn-on time in the time zone that is the estimation target, and determines, as the start-to-sleep determination time, the last turn-off time in the time zone.

[0128] In the estimation process, the estimation device estimates a future last entry estimated time and a future start-to-sleep estimated time of the user based on a past last entry determination time and a past start-to-sleep determination time.

[0129] In the output process, the estimation device outputs the notification or the control instruction related to the operation of the air conditioner based on at least one of the last entry determination time and the start-to-sleep determination time. That is, the bedtime-related time of day estimated in the estimation process can be used for notification to the user or the automatic control of air conditioner 20 in the output process as in the above-described first to third exemplary embodiments.

[0130] Hereinafter, each of the setting process, the determination process, and the estimation process will be more specifically described. Although these processes will be described by using an aspect in which server 10 executes the estimation method as the estimation device, the present disclosure is not limited thereto.

<Setting Process>

[0131] In the setting process, the illuminance threshold for determining the turn-on state or the turn-off state is set based on the illuminance information log including the time-series log data of the illuminance values of the room. As a result, it is possible to set an appropriate illuminance threshold for the room regardless of the presence or absence of a window of the room and a type of lighting device 40.

[0132] Note that, in a case where the illuminance information log includes log data of switch-on or switch-off of lighting device 40, server control unit 14 of server 10 can directly determine the turn-on state or the turn-off state of the room based on the log data of lighting device 40. Thus, in this case, the setting process may not be executed.

[0133] Fig. 7 is a flowchart illustrating an example of step S200 (setting process) according to the fourth exemplary embodiment. Server control unit 14 sets the illuminance threshold based on the illuminance information log of the room over the first predetermined period acquired in step S100 (Fig. 1A). More specifically, in the acquired illuminance information log, server control unit 14 sets the first illuminance threshold for determining whether or not the room is in the turn-off state based on the number of data items corresponding to the illuminance values over the first time zone (step S210). In the later determination process, in a case where the illuminance value is less than or equal to the first illuminance threshold, it may be determined that the room is in the turn-off state at this point in time.

[0134] Here, the first time zone is a time zone related to a sleep time, that is, a time zone in which the room is generally considered to be in the turn-off state. For example, the first time zone may be "00:00 to 06:00", "01:00 to 05:00", or "02:00 to 04:00". The first time zone can be set depending on an area where the room is located or a season in which the illuminance value is detected.

[0135] The log data of the illuminance value is a set of illuminance values detected at regular time intervals (for example, 3 minutes, 5 minutes, or 10 minutes). Thus, the number of data items corresponding to the illuminance values over the first time zone indicates how frequently the room is at the corresponding illuminance value in the first time zone.

[0136] Fig. 8 is a schematic diagram illustrating an example of the first illuminance threshold according to the fourth exemplary embodiment. When a histogram of illuminance values as illustrated in Fig. 8 is created by using the time-series log data of the illuminance values, the number of data items corresponding to the illuminance values can be known. In general, in the first time zone in which the room is considered to be in the turn-off state, the number of data items corresponding to relatively low illuminance values is large, while the number of data items corresponding to relatively high illuminance values is small. In one example, in step S210, server control unit 14 may set, as the first illuminance threshold, an illuminance value having the largest number of corresponding data items. In another example, server con-

trol unit 14 may set, as the first illuminance threshold, an average value of a plurality of (for example, 3 or 5) illuminance values having the largest number of corresponding data items.

[0137] Further, server control unit 14 sets the second illuminance threshold for determining whether or not the room is in the turn-on state based on the illuminance value over a second time zone in the illuminance information log within the first predetermined period (step S220). In the later determination process, in a case where the illuminance value is more than or equal to the second illuminance threshold, it may be determined that the room is in the turn-on state at this point in time.

[0138] In one example, server control unit 14 sets the second illuminance threshold based on increased illuminance values when the illuminance values increase over the second time zone in the illuminance information log within the first predetermined period. For example, server control unit 14 sets, as the second illuminance threshold, an illuminance value having the largest number of corresponding data items among the increased illuminance values.

[0139] In another example, server control unit 14 sets the second illuminance threshold based on the increased illuminance values when the illuminance values increase from the first illuminance threshold or less over the second time zone. That is, in this example, step S220 is executed after step S210.

[0140] The second time zone is a time zone related to before sleeping, that is, a time zone in which the room is generally considered to be in the turn-on state at nighttime. In particular, a time zone in which an occurrence frequency of an action of entering the room and turning on the light is high at nighttime is preferable. For example, the second time zone may be "19:00 to 03:00", "21:00 to 03:00", or "23:00 to 04:00".

[0141] The second time zone can be set depending on the area where the room is located or the season in which the illuminance value is detected.

[0142] In one example, server control unit 14 sets, as the second illuminance threshold, a lowest illuminance value among remaining illuminance values obtained by excluding a part having a low increased illuminance value (for example, the lowest 5%, 10%, or 15% number of data items). Fig. 9 is a schematic diagram illustrating an example of the second illuminance threshold according to the fourth exemplary embodiment. In an upper half part of Fig. 9, the illuminance values over the second time zone are illustrated. A time when the illuminance values increased from the first illuminance threshold or less within the second time zone are represented by dotted rectangles. Such illuminance values and corresponding statistics of the number of data items are illustrated in a lower half part of Fig. 9. As illustrated in the lower half part of Fig. 9, after portions having the lowest 10% number of data items (portions indicated by a dotted block) are excluded, the lowest illuminance value is set as the second illuminance threshold.

[0143] In one example, in the setting process, server control unit 14 further sets an illuminance increase threshold for determining whether or not the room is in the turn-on state. Server control unit 14 sets the illuminance information threshold based on an illuminance increase value (that is, an increase width of the illuminance value before and after the illuminance values are continuous in a time series manner) when the illuminance values increase over the second time zone. In the later determination process, in a case where the illuminance increase value is more than or equal to the illuminance increase threshold, the turn-on state may be determined at a point in time of the increase.

[0144] Fig. 10 is a schematic diagram illustrating an example of the illuminance increase threshold according to the fourth exemplary embodiment. Since data having a small illuminance increase value is considered to be due to shake or noise in measurement by illuminance sensor 25, server control unit 14 excludes a part having a lowest illuminance increase value. Then, server control unit 14 sets the lowest illuminance increase value as the illuminance increase threshold in a data group including the illuminance increase value corresponding to the largest number of data items among the remaining illuminance increase values. The "data group" is referred to as data in which there are one or more illuminance increase values continuously as the number of data items, and is illustrated on a right side of a dotted line in a lower half part of Fig. 10.

[0145] In one example, portions to be excluded are determined as follows. Server control unit 14 sequentially sets first target values for searching for an exclusion threshold in a direction in which the illuminance increase value increases from a minimum illuminance increase value (illuminance increase value 1) in the histogram of the illuminance values, and determines whether or not a currently set first target value satisfies a specific condition. That is, illuminance increase values 1, 2, 3... are sequentially set as the first target values. Specific condition (1) is that both the number of data items corresponding to illuminance increase value "M+1" more than current first target value "M" by 1 and the number of data items corresponding to illuminance increase value "M+2" more than first target value "M" by 2 are 0. Specific condition (2) is that the number of data items corresponding to illuminance increase value "M+1" is more than the number of data items corresponding to first target value "M", and the number of data items corresponding to illuminance increase value "M+2" is more than the number of data items corresponding to illuminance increase value "M+1". That is, specific condition (2) defines that the number of corresponding data items continuously increases twice from the first target value.

[0146] In a case where it is determined that specific condition (1) or specific condition (2) is satisfied, server control unit 14 sets current first target value "M" as the exclusion threshold. Then, server control unit 14 excludes data corresponding to the illuminance increase

value less than or equal to the exclusion threshold. It should be noted that an initial value of the first target value may not be 1. Moreover, the number of times the number of data items is continuously 0 or the number of times the number of data items continuously increases, which is defined in the specific condition may not be 2, and may be, for example, an integer of 3 or more.

[0147] The illuminance increase threshold and the "data group" may also be determined in a similar manner. In one example, server control unit 14 sets second target values for searching for the illuminance increase threshold, and determines whether or not a currently set second target value satisfies a specific condition. Server control unit 14 sequentially sets the second target values in a direction in which the illuminance increase value decreases from the illuminance increase value with the largest number of data ("55" in the example of Fig. 10) in the histogram of the illuminance values as exclusion processing using the exclusion threshold. That is, in the example of Fig. 10, illuminance increase values 55, 54, 53... are sequentially set as the second target values. Specific condition (3) is that the number of data items corresponding to illuminance increase value "N-1" less than current second target value "N" by 1 and the number of data items corresponding to illuminance increase value "N-2" less than second target value "N" by 2 are both 0. Specific condition (4) is that the number of data items corresponding to illuminance increase value "N-1" is more than the number of data items corresponding to second target value "N", and the number of data items corresponding to illuminance increase value "N-2" is more than the number of data items corresponding to illuminance increase value "N-1". That is, specific condition (4) defines that the number of corresponding data items continuously increases twice from the second target value.

[0148] In a case where it is determined that specific condition (3) or specific condition (4) is satisfied, server control unit 14 sets current second target value "N" as the illuminance increase threshold. Then, server control unit 14 sets, as "data group", data corresponding to the illuminance increase value more than or equal to the illuminance increase threshold. It should be noted that there is an initial value of the second target value may not be a maximum value in the histogram, and may be, for example, a value less than a maximum value by a predetermined degree. In addition, the number of times the number of data items is continuously 0 or the number of times the number of data items continuously increases, which is defined in the specific condition may not be 2, and may be, for example, an integer of 3 or more.

[0149] The setting of the first illuminance threshold, the second illuminance threshold, and the illuminance increase threshold described in the fourth exemplary embodiment can be executed in any order, and can be executed in parallel. However, in the example in which the second illuminance threshold is set based on the illuminance value when the illuminance value increases from the first illuminance threshold or less, step S220 is executed after step S210.

[0150] Server control unit 14 stores at least one of the set first illuminance threshold, second illuminance threshold, and illuminance increase threshold in server storage 12 or the like. As a result, the processing of the setting process is completed. In the setting process, at least one of the first illuminance threshold, the second illuminance threshold, and the illuminance increase threshold for determining the turn-on state or the turn-off state of the room is set based on the time-series log data of the illuminance values of the room. As a result, it is possible to set an appropriate illuminance threshold for the room regardless of the presence or absence of the window of the room and the type of the lighting device. For example, even in a case where a bedside lighting other than lighting device 40 mainly used during sleep is used, it is possible to accurately determine the turn-on state or the turn-off state of lighting device 40. In addition, for example, a case where the illumination value increases with a small width and then greatly increases to become a bright turn-on state may not be grasped when only the second illuminance threshold is used. However, the illuminance increase threshold is also used in combination, and thus, it is possible to accurately determine the turn-on state later even in such a case.

[0151] As a result, the setting process can set (train) the first illuminance threshold, the second illuminance threshold, and the illuminance increase threshold for determination. Since these thresholds are set based on an illuminance information log of a specific room, it can be said that these thresholds are optimized for the room. Such a threshold is used, and thus, the turn-on time and the bedtime-related determination time can be more accurately determined.

<Determination process>

[0152] The determination process includes a first half of determining the turn-on time and the turn-off time and a second half of determining the last entry determination time and the start-to-sleep determination time with respect to the log data of the illuminance information log. According to the determination process of the present disclosure, the turn-on time, the turn-off time, the last entry determination time, and the start-to-sleep determination time can be accurately determined. Thus, later, the bedtime-related time of day can also be accurately estimated by using the determination result.

[0153] Note that, in a case where the illuminance information log includes the log data of the switch-on or the switch-off of lighting device 40, server control unit 14 can directly determine the turn-on state or the turn-off state of the room based on the log data of lighting device 40. In this case, the first half of the determination process (determination of the turn-on time and the turn-off time) may not be executed.

[0154] Fig. 11 is a flowchart illustrating an example of

step S300 (determination process) according to the fourth exemplary embodiment. First, server control unit 14 acquires the first illuminance threshold and the second illuminance threshold set based on the illuminance information log within the first predetermined period (step S310). For example, server control unit 14 reads the first illuminance threshold and the second illuminance threshold from server storage 12. In addition, in a case where the illuminance increase threshold is set, the illuminance increase threshold can also be read in step S310.

[0155] Subsequently, server control unit 14 determines at least one of the turn-on time and the turn-off time for the illuminance information log in a third time zone within a past second predetermined period by using the first illuminance threshold and the second illuminance threshold (step S320). In one example, server control unit 14 creates a turn-on label (or referred to as an "ON label") for the determined turn-on time, and creates a turn-off label (or referred to as an "OFF label") for the determined turn-off time.

[0156] Here, the second predetermined period is a period for defining a target of one processing in the determination process. For example, the second predetermined period may be one day, two days, three days, or seven days. In addition, as an example, although the second predetermined period refers to a second predetermined period immediately after a point in time at which the determination process is executed, the present disclosure is not limited thereto.

[0157] The third time zone is a time zone related to nighttime, that is, a time zone generally considered to be nighttime. For example, the third time zone may be "19:00 to 05:00", "20:00 to 04:00", or "21:00 to 03:00". The third time zone can be set depending on the area where the room is located or the season in which the illuminance value is detected.

[0158] Thus, the illuminance information log in the "third time zone within the second predetermined period" that is a processing target of the determination process is, for example, an illuminance information log of the last night (20:00 to 04:00) from the point in time at which the determination process is executed. However, in the illuminance information log in the "third time zone within the second predetermined period", only the turn-on time and the turn-off time may be present, or both the turn-on time and the turn-off time may not be present. In such a case, server control unit 14 determines only the present turn-on time or turn-off time, and creates a corresponding label. In addition, in a case where the second predetermined period is one day or more, the illuminance information log in the third time zone of each day within the second predetermined period is set as the processing target of the determination process.

[0159] Server control unit 14 determines the turn-on time and the turn-off time based on preceding and subsequent illuminance values continuous in a time series manner in the processing target according to various determination conditions. For example, the following first to third determination conditions can be used.

<First determination condition>

[0160] In a case where it is determined that a preceding illuminance value is less than or equal to the first illuminance threshold and a subsequent illuminance value is more than or equal to the second illuminance threshold among the preceding and subsequent illuminance values continuous in a time series manner, server control unit 14 sets a time corresponding to the subsequent illuminance value as the turn-on time.

<Second determination condition>

[0161] In a case where it is determined that the preceding illuminance value is more than or equal to the second illuminance threshold and the subsequent illuminance value is less than or equal to the first illuminance threshold among the preceding and subsequent illuminance values continuous in a time series manner, server control unit 14 sets a time corresponding to the subsequent illuminance value as the turn-off time.

<Third determination condition>

[0162] In a case where it is determined that the subsequent illuminance value is more than the illuminance increase threshold as compared with the preceding illuminance value in the preceding and subsequent illuminance values continuous in a time series manner, server control unit 14 sets a time corresponding to the subsequent illuminance value as the turn-on time.

[0163] In order to further improve determination accuracy, server control unit 14 may exclude a determination result (label) that is unlikely to be related to turn-off immediately before sleep. For example, in a case where the turn-off state continues very short, it is difficult to consider that a turn-off action is an action for sleeping. Thus, server control unit 14 may exclude the determination result (label) satisfying the following fourth determination condition based on a turn-off continuation time. The turn-off continuation time refers to a time during which the turn-on state is continued, and is formed by a series of turn-on time and turn-off time in data.

<Fourth determination condition>

[0164] In a case where it is determined that there is the turn-off continuation time shorter than a turn-off continuation threshold, server control unit 14 excludes a series of turn-on time and turn-off time forming the turn-off continuation time. Note that, the turn-off continuation threshold may be, for example, 3 minutes, 5 minutes, or 10 minutes.

[0165] These determination conditions can be separately used, and any combination of these determination conditions can be used. Server control unit 14 determines

the turn-on time and the turn-off time according to these determination conditions, and creates the corresponding label.

[0166] In a case where the illuminance information log includes the log data of the switch-on or the switch-off of lighting device 40, server control unit 14 may create the label in accordance with the time of switch-on or switch-off recorded in the log data. Server control unit 14 may further process the label created in accordance with the time of switch-on or switch-off according to the fourth determination condition.

[0167] Subsequently, server control unit 14 determines at least one of the last entry determination time and the start-to-sleep determination time of the processing target based on the turn-on time or the turn-off time (step S330). Note that, as described above, the processing target is the illuminance information log in the third time zone of every day within the second predetermined period. The turn-on time or the turn-off time used in step S330 may be the time determined in step S320 or may be the time of switch-on or switch-off recorded in the log data of lighting device 40.

[0168] Fig. 12 is a flowchart illustrating an example of step S330 according to the fourth exemplary embodiment. Server control unit 14 creates, as one pair, a turn-on time and a turn-off time continuous in a time series manner (step S332). That is, server control unit 14 pairs continuous ON label and OFF label with respect to the illuminance information log in one third time zone.

[0169] In one example, in a case where only the OFF label is present in the specific third time zone, in step S332, server control unit 14 creates a virtual ON label corresponding to a start time in the third time zone. Server control unit 14 pairs a virtual ON label and an actually present OFF label.

[0170] Then, server control unit 14 sets, as the last entry determination time in the third time zone, a turn-on time of a latest pair among pairs in the third time zone, and sets a turn-off time of the latest pair as the start-to-sleep determination time in the third time zone (step S334). That is, in a case where the user enters the room and turns on and off lighting device 40 a plurality of times over the third time zone and finally turns off lighting device 40, a latest turn-on time is set as the last entry determination time, and a latest turn-off time is set as the start-to-sleep determination time.

[0171] Note that, in a case where the virtual ON label is created, server control unit 14 does not set a time corresponding to the virtual ON label as the last entry determination time. In this case, only the start-to-sleep determination time is determined in step S334.

[0172] Server control unit 14 stores the determined turn-on time, turn-off time, last entry determination time, and start-to-sleep determination time in server storage 12 or the like. As a result, the processing of the determination process is completed. Server control unit 14 can determine at least one of the last entry determination time and the start-to-sleep determination time in the third time zone of the second predetermined period. In addition, continuous previous turn-on time and subsequent turn-off time is created as one pair, and thus, the determined bedtime-related determination time also follows the order of the previous last entry determination time and the subsequent start-to-sleep determination time.

[0173] Next, another example of the determination process will be described. Figs. 13A and 13B are flowcharts illustrating an example of the determination process according to the fourth exemplary embodiment. This determination process determines the bedtime-related determination time, that is, determines at least one of the last entry determination time and the start-to-sleep determination time.

[0174] In this example, the determination process includes step S601 to step S620. Among them, step S601 corresponds to step S310 in Fig. 11, step S602 to step S606 correspond to step S320 in Fig. 11, and step S608 to step S620 correspond to step S330 in Fig. 11. Then, step S608 to step S616 and step S620 correspond to step S332 in Fig. 12, and step S618 corresponds to step S334 in Fig. 12.

[0175] The description is made with reference to Figs. 14A to 14D together with Figs. 13A and 13B. Fig. 14A is a schematic diagram illustrating an example of label creation according to the fourth exemplary embodiment. Fig. 14B is a schematic diagram illustrating an example of pairing according to the fourth exemplary embodiment. Fig. 14C is a schematic diagram illustrating an example of pairing according to the fourth exemplary embodiment. Fig. 14D is a schematic diagram illustrating an example of the bedtime-related determination time according to the fourth exemplary embodiment.

[0176] First, server control unit 14 acquires the first illuminance threshold and the second illuminance threshold (step S601), and also acquires the illuminance information log in the third time zone over the second predetermined period (step S602). According to the first to third determination conditions described above, server control unit 14 determines at least one of the turn-on time and the turn-off time for the acquired log data, and creates the ON label and the OFF label (step S604). As illustrated in Fig. 14A, the ON label and the OFF label are created for the illuminance information log in the third time zone in step S604.

[0177] Subsequently, server control unit 14 deletes labels before and after the turn-off continuation time shorter than a first time threshold according to the above-described fourth determination condition (step S606). The first time threshold is the above-described turn-off continuation threshold. That is, in step S606, server control unit 14 deletes a series of OFF label and ON label forming the turn-off continuation time shorter than the first time threshold. As illustrated in Fig. 14B, since a turn-off continuation time surrounded by an ellipse is shorter than the first time threshold, the OFF label and the ON label forming the turn-off continuation time are deleted. The deleted result is illustrated in Fig. 14C.

[0178] Subsequently, server control unit 14 determines whether or not there is the OFF label in the third time zone (step S608). Since a case where there is no OFF label indicates that there is no time to start sleeping in the third time zone, the determination process is completed. On the other hand, in a case where there is the OFF label in the third time zone, server control unit 14 further determines whether or not there is the ON label in the third time zone (step S610). In a case where there are both the OFF label and the ON label in the third time zone, server control unit 14 creates, as one pair, an ON label and an OFF label continuous in a time series manner (step S612). That is, server control unit 14 pairs continuous ON label and OFF label.

[0179] In order to further improve the determination accuracy, server control unit 14 may further delete a specific pair. In a case where the turn-on state is continued for a short time, for example, the user may temporarily turn on lighting device 40 in a short time to check a smartphone or go to a toilet. Since such a turn-on and turn-off action may not be an action for sleeping, it is conceivable to delete a pair having a relatively short turn-on continuation time. However, in a case where there is not only such a pair in the third time zone, it cannot be determined to delete the pair. Here, only in a case where there is a pair having a relatively long turn-on continuation time, server control unit 14 deletes a pair having a relatively short turn-on continuation time. Note that, the turn-on continuation time refers to a time during which the turn-on state is continued, and is formed by a series of turn-on time and turn-off time in data.

[0180] Server control unit 14 first determines whether or not there is a pair of which the turn-on continuation time is more than or equal to the second time threshold (step S614). That is, server control unit 14 determines whether there is a pair having a relatively long turn-on continuation time. In a case where there is a pair of which the turn-on continuation time is more than or equal to the second time threshold, server control unit 14 deletes a pair having a turn-on continuation time shorter than the second time threshold (step S616). On the other hand, in a case where there is no pair of which the turn-on continuation time is more than or equal to the second time threshold, a pair of which the turn-on continuation time is relatively short is also used for determination.

[0181] For example, in Fig. 14C, there are three pairs of pair (1) to pair (3). It is assumed that the turn-on continuation times of pair (1) and pair (2) are more than or equal to the second time threshold, and the turn-on continuation time of pair (3) is shorter than the second time threshold. In this case, since there is a pair of which the turn-on continuation time is more than or equal to the second time threshold, server control unit 14 deletes pair (3). Note that, the second time threshold may be, for example, 5 minutes, 10 minutes, 15 minutes, or 30 minutes.

[0182] When pairing processing ends, server control unit 14 determines at least one of the last entry determination time and the start-to-sleep determination time by using the remaining pair (step S618). Here, server control unit 14 may determine the last entry determination time or the start-to-sleep determination time in a manner similar to step S334 described above. That is, server control unit 14 sets, as the last entry determination time in the third time zone, the turn-on time of the latest pair among the pairs remaining in the third time zone, and sets the turn-off time of the latest pair as the start-to-sleep determination time in the third time zone.

[0183] Although pair (1) to pair (3) illustrated in Fig. 14D are created in step S612, since the turn-on continuation time is shorter than the second time threshold, pair (3) is deleted in step S616. Then, only pair (1) and pair (2) remain in the third time zone. Since pair (2) is the latest pair among the pairs remaining in the third time zone, server control unit 14 sets the turn-on time of pair (2) as the last entry determination time in the third time zone, and sets the turn-off time of pair (2) as the start-to-sleep determination time in the third time zone.

[0184] In a case where it is determined in step S608 and step S610 that there is only the OFF label in the third time zone, server control unit 14 executes step S618. That is, server control unit 14 extracts the OFF label having the latest time in the third time zone (step S620), and determines the start-to-sleep determination time (step S618). More specifically, as in step S332 described above, server control unit 14 creates the virtual ON label, and creates a virtual pair by pairing the virtual ON label and the actually present OFF label. Since there is no other pair in the third time zone, server control unit 14 determines the bedtime-related determination time by using the virtual pair. Server control unit 14 extracts the OFF label of the virtual pair in step S620, and determines, as the start-to-sleep determination time, the turn-off time corresponding to the OFF label extracted in step S618.

[0185] As a result, the processing of the determination process is completed. Server control unit 14 can more accurately determine the bedtime-related determination time in the third time zone of the second predetermined period. In addition, the ON label and the OFF label are paired, and thus, a determination result in which an actual occurrence order is reversed does not occur at the determined bedtime-related determination time.

<Estimation Process>

[0186] In the estimation process, the estimation device estimates at least one of the future last entry estimated time and start-to-sleep estimated time of the user based on the past last entry determination time and start-to-sleep determination time. Note that, the last entry estimated time and the start-to-sleep estimated time can be executed independently of each other.

[0187] As described above, the bedtime-related determination time includes the last entry determination time and the start-to-sleep determination time, and the bedtime-related time of day includes the last entry estimated time and the start-to-sleep estimated time. Server control

unit 14 may estimate each of the last entry determination time and the start-to-sleep determination time by a similar method. The estimation process will be described below with reference to Figs. 15 and 16 by using superordinate concepts of "bedtime-related determination time" and "bedtime-related time of day". However, the "bedtime-related determination time" in the description can be replaced with the "last entry determination time", the "start-to-sleep determination time", or "last entry determination time and start-to-sleep determination time". Similarly, the "bedtime-related determination time" in the description can be replaced with the "last entry estimated time", the "start-to-sleep estimated time", or the "last entry estimated time and start-to-sleep estimated time".

[0188] Fig. 15 is a flowchart illustrating an example of step S400 (estimation process) according to the fourth exemplary embodiment. Server control unit 14 acquires the bedtime-related determination time (step S410). For example, server control unit 14 reads the turn-on time, the turn-off time, the last entry determination time, and the start-to-sleep determination time which are determined based on the illuminance information log and are stored in server storage 12. Note that, server control unit 14 may acquire only the portions used for estimation, that is, only the portions corresponding to the past third predetermined period.

[0189] The third predetermined period can be determined by the amount of data necessary for sufficiently accurately estimating the bedtime-related time of day. Hereinafter, the description will be given by using an example in which the third predetermined period is 35 days as in the first predetermined period, but the present disclosure is not limited to this period. In addition, as an example, the third predetermined period refers to a third predetermined period immediately after a point in time at which the estimation method is executed, but the present disclosure is not limited thereto.

[0190] Server control unit 14 calculates a median of the acquired bedtime-related determination times (step S420), and sets the median of the bedtime-related determination times as the bedtime-related related time of day (step S430). It should be noted that there may be a day on which the bedtime-related determination time (at least one of the last entry determination time and the start-to-sleep determination time) cannot be determined depending on the content of the illuminance information log. Server control unit 14 may calculate the median while ignoring the bedtime-related determination time that cannot be determined.

[0191] For example, server control unit 14 acquires last entry determination times for latest 35 days in step S410, and calculates a median of the last entry determination times for 35 days in step S420. In a case where there are no last entry determination times for two days on latest 35 days, server control unit 14 calculates a median of last entry determination times for remaining 33 days, and sets the median as the last entry estimated time.

[0192] In one example, in order to more accurately perform estimation, server control unit 14 calculates and estimates an overall median and day-of-week medians.

[0193] In this example, in step S420, server control unit 14 calculates the overall median and the day-of-week medians of the acquired bedtime-related determination times. For example, server control unit 14 calculates the overall median of the last entry determination times by using all of the acquired last entry determination times. In addition, server control unit 14 calculates the median of Monday by using the bedtime-related determination time corresponding to Monday, and similarly calculates the median of each day of the week by using the bedtime-related determination time corresponding to each day of the week from Tuesday to Saturday.

[0194] Fig. 16 is a flowchart illustrating an example of step S430 according to this example. Server control unit 14 calculates errors between the overall median of the bedtime-related determination times and the actually determined bedtime-related determination times. Then, server control unit 14 calculates errors between the day-of-week medians of the bedtime-related times of day and the actually determined bedtime-related determination times (step S432). A method for calculating the error will be described later with reference to Figs. 18A and 19B.

[0195] Subsequently, server control unit 14 sets, as the bedtime-related time of day, the median having a smaller error, of the overall median of the bedtime-related determination times and the day-of-week medians of the bedtime-related times of day (step S434). For example, the median having a smaller error, of the overall median and the day-of-week medians of the last entry determination times, is set as the last entry estimated time, and the median having a smaller error, of the overall median and the day-of-week medians of the start-to-sleep determination times, is set as the start-to-sleep estimated time.

[0196] Next, another example of the estimation process will be described. Fig. 17 is a flowchart illustrating an example of the estimation process according to the fourth exemplary embodiment. In this estimation process, it is possible to obtain an estimation result that follows the order of the preceding last entry estimated time and the subsequent start-to-sleep estimated time.

[0197] In this example, the estimation process includes step S702 to step S712. Among them, step S702 is substantially similar to step S410 in Fig. 15, and step S704 corresponds to step S420 and step S430 in Fig. 15.

[0198] In the estimation process of Fig. 17, server control unit 14 first acquires the bedtime-related determination time over the third predetermined period (step S702). Then, as in step S420 and step S430 described above, server control unit 14 calculates the median of the bedtime-related determination times and provisionally estimates the bedtime-related time of day (step S704). In this estimation process, the bedtime-related time of day obtained in step 704 is regarded as a provisional estimation result. The provisional estimation result is confirmed after check in step S706 and step S708, and is output as a final estimation result.

[0199] Server control unit 14 determines whether or not there are both the last entry estimated time and the start-to-sleep estimated time in the third time zone with respect to the provisional estimation result (step S706). In a case where there is only one of the last entry estimated time and the start-to-sleep estimated time, the provisionally estimated bedtime-related time of day is confirmed as the final estimation result (step S710).

[0200] On the other hand, in a case where there are both the last entry estimated time and the start-to-sleep estimated time, server control unit 14 further determines whether or not the last entry estimated time is not later than the start-to-sleep estimated time (step S708). In a case where the last entry estimated time is not later than the start-to-sleep estimated time, that is, in a case where the time is not reversed in the provisional estimation result, the provisionally estimated bedtime-related time of day is confirmed as the final estimation result (step S710).

[0201] In the provisional estimation result, in a case where the reversal of the time in which the last entry estimated time is later than the start-to-sleep estimated time occurs, server control unit 14 may provisionally estimate the bedtime-related time of day again. For example, server control unit 14 extracts a bedtime-related determination time of a day on which there are both the last entry determination time and the start-to-sleep determination time over the third predetermined period (step S712), and performs provisional estimation again by using the extracted data (step S704). That is, the bedtime-related determination time on a day on which there is only the last entry determination time and on a day on which there is only the start-to-sleep determination time are not used for performing provisional estimation again.

[0202] As described above, in a case where there are both the last entry determination time and the start-to-sleep determination time by pairing, the reverse does not occur at the two times. Thus, in a case where only the data on the day on which there are both the last entry determination time and the start-to-sleep determination time is estimated, it is possible to ensure that the time is not reversed in the estimation result.

[0203] In one example, in step S708, it is determined whether or not there is a combination in which the last entry estimated time is not later than the start-to-sleep estimated time among the following combinations 1 to 4.

(Combination 1) combination of last entry estimated time (overall median) and start-to-sleep estimated time (overall median)

(Combination 2) combination of last entry estimated time (overall median) and start-to-sleep estimated time (day-of-week median)

(Combination 3) combination of last entry estimated time (day-of-week median) and start-to-sleep estimated time (overall median)

(Combination 4) combination of last entry estimated time (day-of-week median) and start-to-sleep estimated time (day-of-week median)

[0204] For example, for Combination 1, server control unit 14 determines whether or not the overall median of the last entry estimated time is later than the overall median of the start-to-sleep estimated time. Combinations 2 to 4 are also determined by the same logic.

[0205] In a case where there is an established combination among combinations 1 to 4, server control unit 14 confirms the bedtime-related time of day provisionally estimated by the combination. For example, when combination 2 is determined, the overall median "23:00" of the last entry estimated times is not later than the day-of-week median "01:00" of the start-to-sleep estimated time. In this case, "23:00" is finally confirmed as the last entry estimated time, and "01:00" is finally confirmed as the start-to-sleep estimated time.

[0206] Hereinafter, a method for estimating the bedtime-related time of day by calculating errors between the median of the bedtime-related determination times and the actually determined bedtime-related determination times will be described with reference to Figs. 18A to 19B. Fig. 18A is a flowchart illustrating an example of estimation based on an overall median in the fourth exemplary embodiment. Fig. 18B is a flowchart illustrating an example of estimation based on the day-of-week median in the fourth exemplary embodiment. Fig. 19A is a schematic diagram illustrating an example of error calculation based on the overall median in the fourth exemplary embodiment. Fig. 19B is a schematic diagram illustrating an example of error calculation based on the day-of-week median in the fourth exemplary embodiment.

[0207] Server control unit 14 may calculate an error for each of the last entry determination time and the start-to-sleep determination time by a similar method. In the description of Figs. 18A to 19B, the estimation process will be described by using a superordinate concept of "bedtime-related determination time", but "bedtime-related determination time" in the description can be replaced with "last entry determination time" or "start-to-sleep determination time".

[0208] Step S802 and step S822 in this example correspond to step S420 in Fig. 15, and step S804 to step S810 and step S824 to step S830 correspond to step S430 in Fig. 15. Note that, all of step S802 to step S810 and step S822 to step S830 can be included in step S704 in Fig. 17.

[0209] First, the estimation based on the overall median illustrated in Fig. 18A will be described. Server control unit 14 calculates the overall median of the bedtime-related determination times over the third predetermined period (step S802). It is assumed that server control unit 14 calculates the overall median "23:00" based on data array (1) (bedtime-related determination time) illustrated in Fig. 19A.

[0210] Subsequently, server control unit 14 sets the provisional estimated time for a fourth predetermined period based on the overall median (step S804). The fourth predetermined period can be set according to an execution frequency of the estimation method. For example, in

a case where the estimation device executes the estimation method every week to estimate bedtime-related times of day for seven days of the next week, the fourth predetermined period is set to seven days or more. Basically, the fourth predetermined period is set to be shorter than the third predetermined period. In the example of Figs. 18A to 19B, the fourth predetermined period is set to seven days.

[0211] In step S804, server control unit 14 sets all the provisional estimated times for the fourth predetermined period (for one week) to the overall median. That is, the provisional estimated times for the fourth predetermined period are all the same numerical values. As illustrated in data array (2) in Fig. 19A, all the provisional estimated times for the fourth predetermined period based on the overall median "23:00" are set to "23:00".

[0212] Server control unit 14 calculates and stores errors between the provisional estimated times and the actually determined bedtime-related determination times (step S806). In one example, a time difference obtained by subtracting the corresponding bedtime-related determination time from the provisional estimated time for each day of the fourth predetermined period is calculated as an error. As illustrated in data array (3) in Fig. 19A, in a case where the bedtime-related determination time is ahead of the provisional estimated time, the error is subtracted. A unit of error is minutes. For example, an error from the bedtime-related determination time "23:30" corresponding to the same day as the provisional estimated time "23:00" on Monday is "-30 (minutes)".

[0213] In one example, when the error of the overall median for the latest fourth predetermined period is calculated, server control unit 14 stores the error (that is, data array (3) in Fig. 19A) in server storage 12. By doing this, whenever the estimation process is executed, an error of an overall median for a new fourth predetermined period is calculated and stored in server storage 12.

[0214] Subsequently, server control unit 14 acquires the error of the overall median over the third predetermined period (step S808). For example, in a case where the third predetermined period is set to 35 days, server control unit 14 reads the errors of the overall median for latest 35 days from server storage 12. Since the fourth predetermined period is set to be shorter than the third predetermined period, the acquired errors includes the errors calculated in step S806. An example of the errors of the overall median over the third predetermined period is illustrated in data array (4) of Fig. 19A.

[0215] Subsequently, server control unit 14 calculates a mean absolute error (MAE) for each day of the week based on the acquired errors (step S810). For example, server control unit 14 calculates MAE for Monday by using errors corresponding to Monday in 35 days. The calculated MAE for each day of the week is illustrated in data array (5) of Fig. 19A. Server control unit 14 uses the MAE for each day of the week as an index for determining the magnitude of the error.

[0216] Next, the estimation based on the day-of-week medians illustrated in Fig. 18B will be described. There is a difference between the processing illustrated in Fig. 18B and the processing illustrated in Fig. 18A in a median to be used. Other processing methods are the same as the processing illustrated in Fig. 18B and the processing illustrated in Fig. 18A.

[0217] In the processing illustrated in Fig. 18B, server control unit 14 calculates the day-of-week medians of the bedtime-related determination times over the third predetermined period based on the bedtime-related determination time (data array (6) in Fig. 19B) (step S822). Subsequently, server control unit 14 sets the provisional estimated time (data array (7) in Fig. 19B) for the fourth predetermined period based on the median (step S824). server control unit 14 calculates and stores errors (data array (8) in Fig. 19B) between the provisional estimated times based on the day-of-week medians and the actually determined bedtime-related determination times (step S826). Then, server control unit 14 acquires the errors of the day-of-week medians over the third predetermined period (data array (9) in Fig. 19B) from server storage 12 (step S828). Based on the acquired errors, server control unit 14 calculates the MAE (data array (10) in Fig. 19B) for each day of the week (step S830).

[0218] According to the processing illustrated in Figs. 18A and 18B, server control unit 14 acquires "last entry estimated time (overall median)", "last entry estimated time (day-of-week median)", "start-to-sleep estimated time (overall median)", and "start-to-sleep estimated time (day-of-week median)" in step S804 and step S824. Further, in step S810 and step S830, server control unit 14 acquires "MAE for each day of the week based on the overall median of the last entry determination times", "MAE for each day of the week based on the day-of-week medians of the last entry determination times", "MAE for each day of the week based on the overall median of the start-to-sleep determination times", and "MAE for each day of the week based on the day-of-week medians of the start-to-sleep determination times".

[0219] Thereafter, server control unit 14 executes step S706 to step S712 in Fig. 17 by using these estimated times, and can output the final estimation result.

[0220] In one example, in a case where it is determined in step S708 that there are a plurality of combinations in which the last entry estimated time is not later than the start-to-sleep estimated time, server control unit 14 determines the bedtime-related time of day based on the sum of the MAEs in step S710. More specifically, the provisional estimation result corresponding to the combination in which the sum of the MAE of the last entry estimated times and the MAE of the start-to-sleep estimated times is the smallest among the plurality of combinations is determined as the final estimation result.

[0221] For example, in "Combination 1: combination of last entry estimated time (overall median) and start-to-sleep estimated time (overall median)" and "Combination 2: combination of last entry estimated time (overall median) and start-to-sleep estimated time (day-of-week

median)", it is assumed that the last entry estimated time is not later than the start-to-sleep estimated time. Server control unit 14 sets a result obtained by adding the MAE corresponding to the last entry estimated time (overall median) and the MAE corresponding to the start-to-sleep estimated time (overall median) as an error value of Combination 1. Similarly, server control unit 14 sets a result obtained by adding the MAE corresponding to the last entry estimated time (overall median) and the MAE corresponding to the start-to-sleep estimated time (day-of-week median) as an error value of Combination 2. In a case where the error value of Combination 1 is smaller than the error value of Combination 2, server control unit 14 confirms the last entry estimated time (overall median) as the final estimated result of the last entry estimated time, and confirms the start-to-sleep estimated time (overall median) as the final estimated result of the start-to-sleep estimated time.

[0222] As a result, the processing of the estimation process is completed. Server control unit 14 calculates the overall median and the day-of-week medians of the bedtime-related determination times, further calculates errors, and sets the estimated time having a smaller error as the bedtime-related time of day. Thus, the estimation process can more accurately estimate the bedtime-related time of day.

[0223] Note that, as described in the first to third exemplary embodiments, the estimated bedtime-related time of day can be used for notification or automatic control related to the operation of the air conditioner in the output process.

[0224] The setting process, the determination process, the estimation process, and the output process described above do not need to be continuously executed, and can be executed independently of each other. In addition, each process has a plurality of technical features, but these technical features are also independently executable. These technical features can be voluntarily combined. The estimation device performs the estimation method by executing voluntarily combined techniques based on the illuminance information log. For example, the estimation device may determine the turn-on time and the turn-off time only based on the first determination condition and the second determination condition, and may output the notification to the information terminal based on the estimated bedtime-related time of day. For example, the estimation device may estimate the bedtime-related time of day in the determination process illustrated in Figs. 13A and 13B and the estimation process illustrated in Fig. 17, and may control the air conditioner based on the estimated bedtime-related time of day.

[0225] The above embodiment is merely a specific exemplary embodiment of the present disclosure, and the protection scope of the present disclosure is not limited thereto. The present disclosure includes the contents described above in the drawings and the specific exemplary embodiment described above, but the present disclosure is not limited thereto. Various disclosed exemplary embodiments or examples may be combined without departing from the scope or spirit of the present disclosure. Changes that do not depart from functional and structural principles of the present disclosure are within the scope of the claims.

REFERENCE MARKS IN THE DRAWINGS

[0226]

10: server
12: server storage
14: server control unit
16: server communication unit
20: air conditioner
21: air-conditioning storage
22: air-conditioning control unit
23: air-conditioning communication unit
24: temperature sensor
25: illuminance sensor
30: information terminal
32: related application
40: lighting device
SC1 to SC3: screen
R1 to R7: display region

Claims

1. A method for estimating a bedtime-related time of day of a user of an air conditioner, the method comprising:

acquiring an illuminance information log of a room as an air-conditioning control target of the air conditioner over a past first predetermined period;
estimating a bedtime-related time of day related to sleeping of the user in the room based on the illuminance information log; and
outputting, to an information terminal, the bedtime-related time of day and notification information related to an operation of the air conditioner.

2. The method for estimating a bedtime-related time of day according to Claim 1, wherein

the bedtime-related time of day includes a last entry estimated time when the user finally enters the room before sleeping, and
in the outputting, the last entry estimated time and the notification information are output to the information terminal at a time before a first predetermined time period from the last entry estimated time.

3. A method for estimating a bedtime-related time of

day of a user of an air conditioner, the method comprising:

acquiring an illuminance information log of a room as an air-conditioning control target of the air conditioner over a past first predetermined period;
estimating a bedtime-related time of day related to sleeping of the user in the room based on the illuminance information log; and
outputting, to the air conditioner, control instructions for the air conditioner to operate based on the bedtime-related time of day.

4. The method for estimating a bedtime-related time of day according to Claim 3, wherein

the bedtime-related time of day includes a last entry estimated time when the user finally enters the room before sleeping, and
in the outputting, the control instruction to activate the air conditioner is output to the air conditioner at a time before a first predetermined time period from the last entry estimated time.

5. The method for estimating a bedtime-related time of day according to Claim 3, wherein

the bedtime-related time of day includes a start-to-sleep estimated time when the user finally turns off light in the room before sleeping, and
in the outputting, when a second predetermined time elapses from the start-to-sleep estimated time, in a case where it is determined that the air conditioner is operating, the control instruction to switch the air conditioner to a sleep-related mode is output to the air conditioner.

6. The method for estimating a bedtime-related time of day according to any one of Claims 1 to 5, wherein

the illuminance information log includes time-series log data of illuminance values of the room, and
the method for estimating a bedtime-related time of day further includes

setting a first illuminance threshold for determining whether or not the room is in a turn-off state based on a number of data items corresponding to illuminance values over a first time zone related to a sleep time in the illuminance information log within the first predetermined period, and
setting a second illuminance threshold for determining whether or not the room is in a turn-on state based on increased illuminance values when illuminance values increase over a second time zone related to before sleeping in the illuminance information log within the first predetermined period.

7. The method for estimating a bedtime-related time of day according to any one of Claims 1 to 6, further comprising:

acquiring a first illuminance threshold and a second illuminance threshold set based on the illuminance information log within the first predetermined period;
determining at least one of a turn-on time and a turn-off time for the illuminance information log in a third time zone related to nighttime within a past second predetermined period by using the first illuminance threshold and the second illuminance threshold; and
determining at least one of a last entry determination time and a start-to-sleep determination time in the third time zone within the second predetermined period based on the determined turn-on time or turn-off time,
wherein in the estimating of the bedtime-related time of day, the bedtime-related time of day is estimated based on the last entry determination time or the start-to-sleep determination time.

8. The method for estimating a bedtime-related time of day according to Claim 7, wherein the determining of at least one of the last entry determination time and the start-to-sleep determination time includes

creating, as one pair, the determined turn-on time and the determined turn-off time continuous in a time series manner, and
setting a turn-on time of a latest pair, among created pairs in the third time zone, as the last entry determination time in the third time zone, and a turn-off time of the latest pair as the start-to-sleep determination time in the third time zone.

9. The method for estimating a bedtime-related time of day according to any one of Claims 1 to 8, wherein the estimating of the bedtime-related time of day includes

acquiring bedtime-related determination times within a portion corresponding to a past third predetermined period, among bedtime-related determination times determined based on the illuminance information log,
calculating a median of the acquired bedtime-related determination times, and
setting the median of the bedtime-related determination times as the bedtime-related time of

day.

10. The method for estimating a bedtime-related time of day according to Claim 9, wherein

in the calculating of the median of the acquired bedtime-related determination times, an overall median and day-of-week medians of the acquired bedtime-related determination times are calculated, and
the setting of the median of the bedtime-related determination times as the bedtime-related time of day includes

calculating errors between the overall median of the bedtime-related determination times and the determined bedtime-related determination times and errors between day-of-week medians of the bedtime-related times of day and the determined bedtime-related determination times, and
setting, as the bedtime-related time of day, the median having a smaller error, of the overall median of the bedtime-related determination times and the day-of-week medians of the bedtime-related times of day.

11. A device for estimating a bedtime-related time of day of a user of an air conditioner, the device configured to:

acquire an illuminance information log of a room as an air-conditioning control target of the air conditioner over a past first predetermined period;
estimate a bedtime-related time of day related to sleeping of the user in the room based on the illuminance information log; and
output, to an information terminal, the bedtime-related time of day and notification information related to an operation of the air conditioner.

12. The device for estimating a bedtime-related time of day according to Claim 11, wherein

the bedtime-related time of day includes a last entry estimated time when the user finally enters the room before sleeping, and
the device configured to estimate the bedtime-related time of day is further configured to output, to the information terminal, the last entry estimated time and the notification information at a time before a first predetermined time period from the last entry estimated time.

13. A device for estimating a bedtime-related time of day of a user of an air conditioner, the device configured to:

acquire an illuminance information log of a room as an air-conditioning control target of the air conditioner over a past first predetermined period;
estimate a bedtime-related time of day related to sleeping of the user in the room based on the illuminance information log; and
output, to the air conditioner, control instructions for the air conditioner to operate based on the bedtime-related time of day.

14. The device for estimating a bedtime-related time of day according to Claim 13, wherein

the bedtime-related time of day includes a last entry estimated time when the user finally enters the room before sleeping, and
the device configured to estimate the bedtime-related time of day is further configured to output, to the air conditioner, the control instruction to activate the air conditioner at a time before a first predetermined time period from the last entry estimated time.

15. The device for estimating a bedtime-related time of day according to Claim 13, wherein

the bedtime-related time of day includes a start-to-sleep estimated time when the user finally turns off light in the room before sleeping, and
the device configured to estimate the bedtime-related time of day is further configured to output, to the air conditioner, the control instruction to switch the air conditioner to a sleep-related mode, in a case where it is determined that the air conditioner is operating, when a second predetermined time elapses from the start-to-sleep estimated time.

16. The device for estimating a bedtime-related time of day according to any one of Claims 11 to 15, wherein

the illuminance information log includes time-series log data of illuminance values of the room, and
the device configured to estimates the bedtime-related time of day is further configured to

set a first illuminance threshold for determining whether or not the room is in a turn-off state based on a number of data items corresponding to illuminance values over a first time zone related to a sleep time in the illuminance information log within the first predetermined period, and
set a second illuminance threshold for determining whether or not the room is in a turn-on state based on increased illumi-

nance values when illuminance values increase over a second time zone related to before sleeping in the illuminance information log within the first predetermined period.

17. The device for estimating a bedtime-related time of day according to any one of Claims 11 to 16, the device further configured to:

acquire a first illuminance threshold and a second illuminance threshold set based on the illuminance information log within the first predetermined period;
determine at least one of a turn-on time and a turn-off time for the illuminance information log in a third time zone related to nighttime within a past second predetermined period by using the first illuminance threshold and the second illuminance threshold; and
determine at least one of a last entry determination time and a start-to-sleep determination time in the third time zone within the second predetermined period based on the determined turn-on time or turn-off time,
wherein the device configured to estimate the bedtime-related time of day is further configured to estimate the bedtime-related time of day based on the last entry determination time or the start-to-sleep determination time, when the bedtime-related time of day is estimated.

18. The device for estimating a bedtime-related time of day according to Claim 17, wherein when at least one of the last entry determination time and the start-to-sleep determination time is determined, the device configured to estimate the bedtime-related time of day is further configured to

create, as one pair, the determined turn-on time and the determined turn-off time continuous in a time series manner, and
set a turn-on time of a latest pair, among created pairs in the third time zone, as the last entry determination time in the third time zone, and a turn-off time of the latest pair as the start-to-sleep determination time in the third time zone.

19. The device for estimating a bedtime-related time of day according to any one of Claims 11 to 18, wherein when the bedtime-related time of day is estimated, the device configured to estimate the bedtime-related time of day is further configured to

acquire bedtime-related determination times within a portion corresponding to a past third predetermined period, among bedtime-related determination times determined based on the illuminance information log,
calculate a median of the acquired bedtime-related determination times, and
set the median of the bedtime-related determination times as the bedtime-related time of day.

20. The device for estimating a bedtime-related time of day according to Claim 19, wherein

when the median of the acquired bedtime-related determination times is calculated, the device configured to estimate the bedtime-related time of day is further configured to calculate an overall median and day-of-week medians of the acquired bedtime-related determination times, and
when the median of the bedtime-related determination times is set as the bedtime-related time of day, the device configured to estimate the bedtime-related time of day is further configured to

calculate, errors between the overall median of the bedtime-related determination times and the determined bedtime-related determination times and errors between day-of-week medians of the bedtime-related times of day and the determined bedtime-related determination times, and
set, as the bedtime-related time of day, the median having a smaller error, of the overall median of the bedtime-related determination times and the day-of-week medians of the bedtime-related times of day.

FIG. 1A

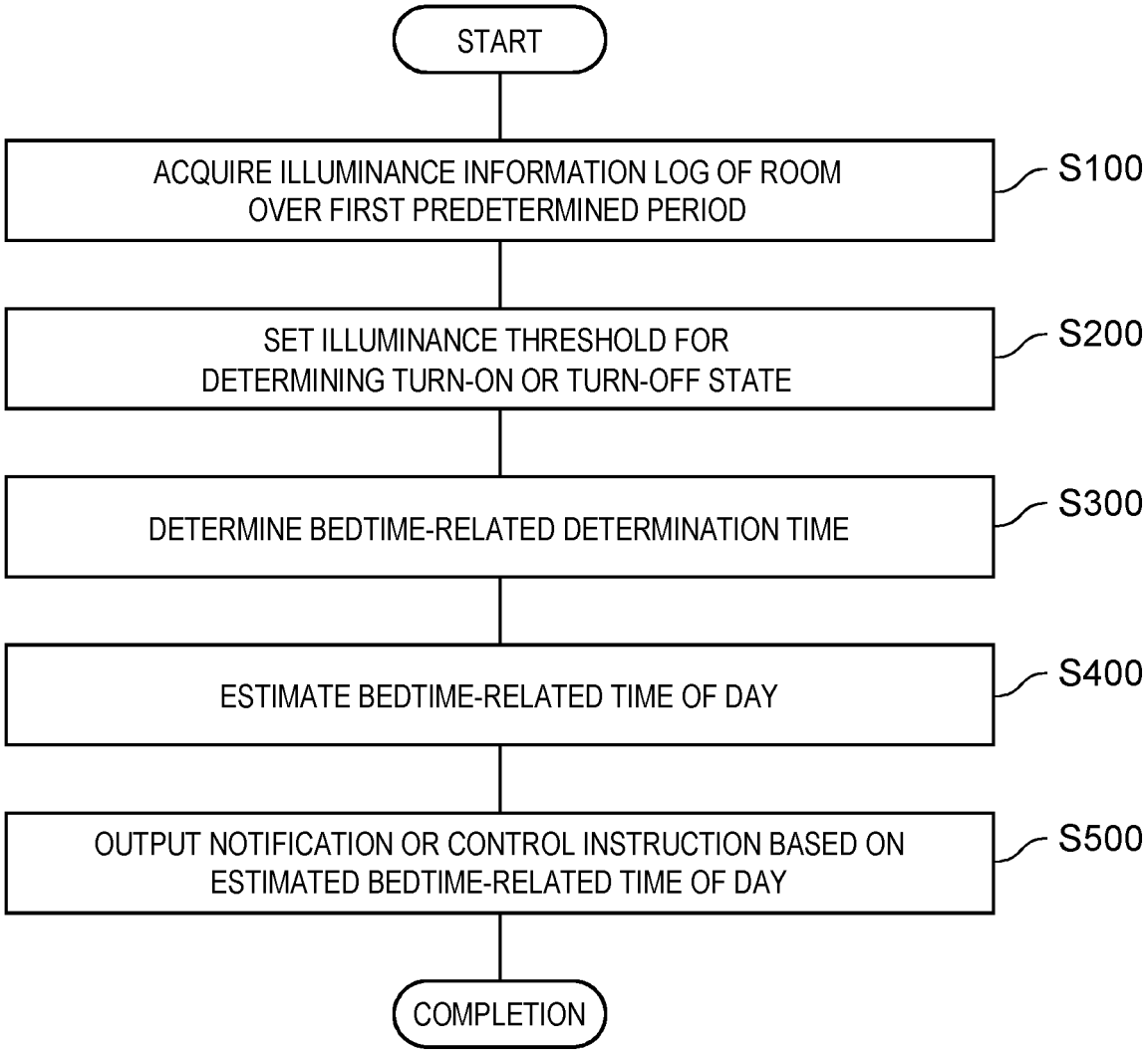
START
ACQUIRE ILLUMINANCE INFORMATION LOG OF ROOM OVER FIRST PREDETERMINED PERIOD
S100
SET ILLUMINANCE THRESHOLD FOR DETERMINING TURN-ON OR TURN-OFF STATE
S200
DETERMINE BEDTIME-RELATED DETERMINATION TIME
S300
ESTIMATE BEDTIME-RELATED TIME OF DAY
S400
OUTPUT NOTIFICATION OR CONTROL INSTRUCTION BASED ON ESTIMATED BEDTIME-RELATED TIME OF DAY
S500
COMPLETION

FIG. 1B

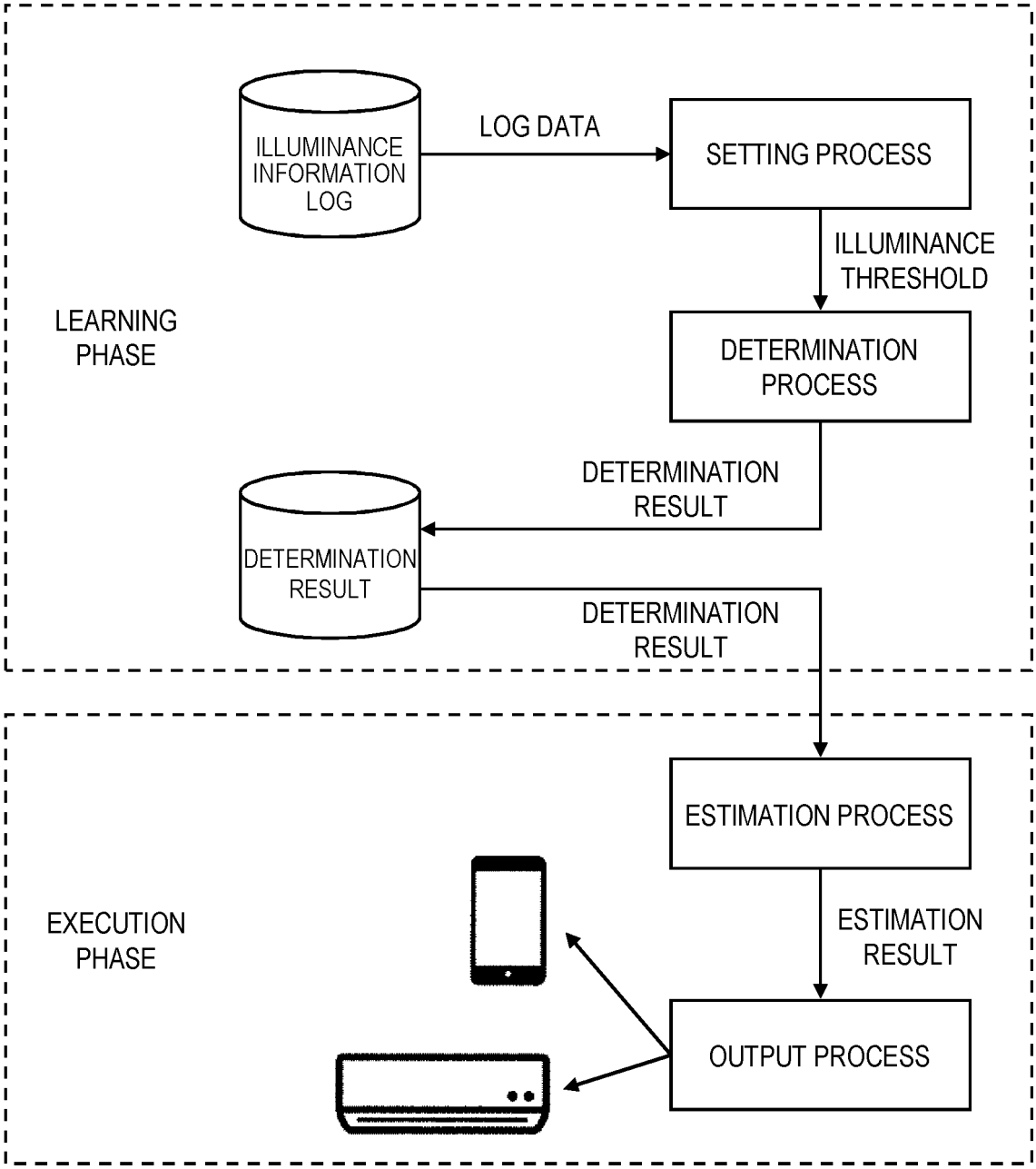
ILLUMINANCE INFORMATION LOG
LOG DATA
SETTING PROCESS
ILLUMINANCE THRESHOLD
LEARNING PHASE
DETERMINATION PROCESS
DETERMINATION RESULT
DETERMINATION RESULT
DETERMINATION RESULT
ESTIMATION PROCESS
EXECUTION PHASE
ESTIMATION RESULT
OUTPUT PROCESS

FIG. 1C

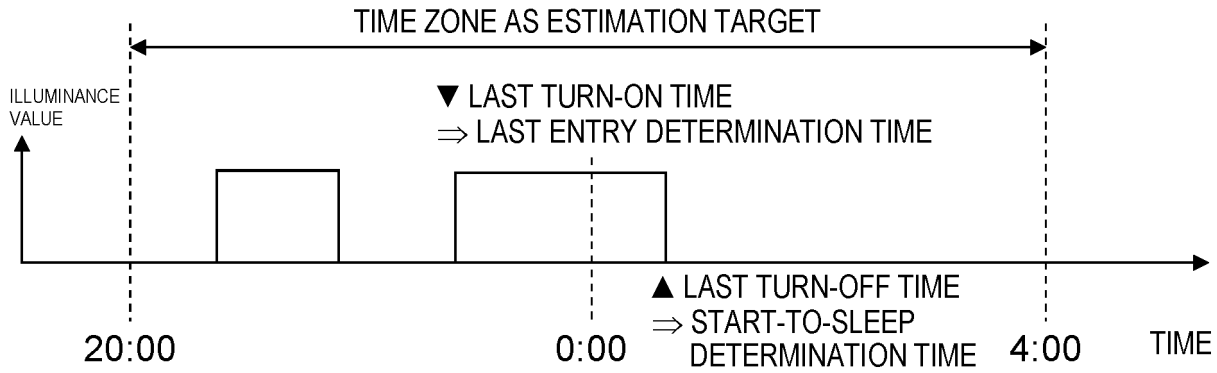
TIME ZONE AS ESTIMATION TARGET
ILLUMINANCE VALUE
▼ LAST TURN-ON TIME
⇒ LAST ENTRY DETERMINATION TIME
▲ LAST TURN-OFF TIME
⇒ START-TO-SLEEP DETERMINATION TIME
20:00
0:00
4:00
TIME

FIG. 2

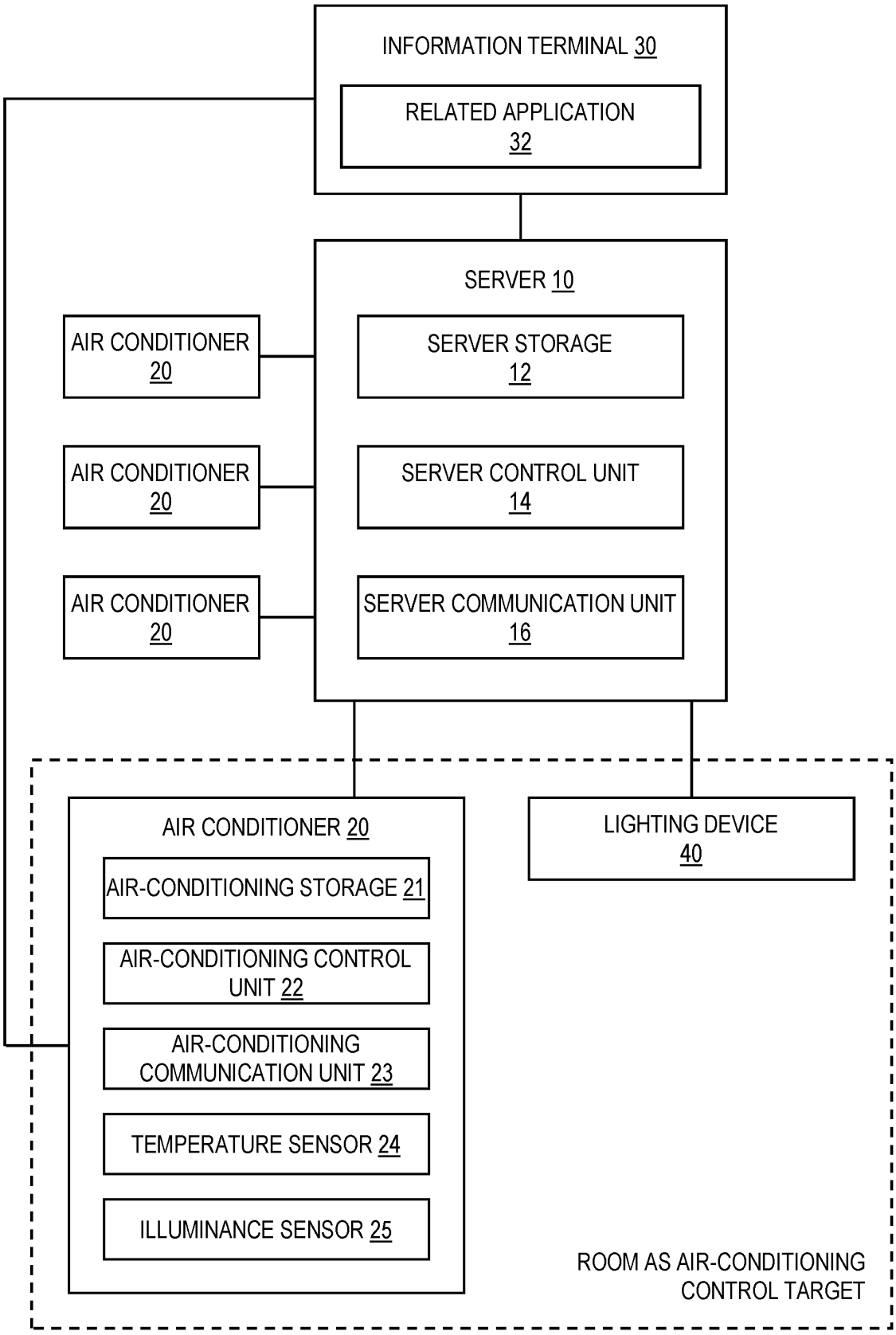
INFORMATION TERMINAL 30
RELATED APPLICATION 32
SERVER 10
AIR CONDITIONER 20
AIR CONDITIONER 20
AIR CONDITIONER 20
SERVER STORAGE 12
SERVER CONTROL UNIT 14
SERVER COMMUNICATION UNIT 16
AIR CONDITIONER 20
AIR-CONDITIONING STORAGE 21
AIR-CONDITIONING CONTROL UNIT 22
AIR-CONDITIONING COMMUNICATION UNIT 23
TEMPERATURE SENSOR 24
ILLUMINANCE SENSOR 25
LIGHTING DEVICE 40
ROOM AS AIR-CONDITIONING CONTROL TARGET

FIG. 3

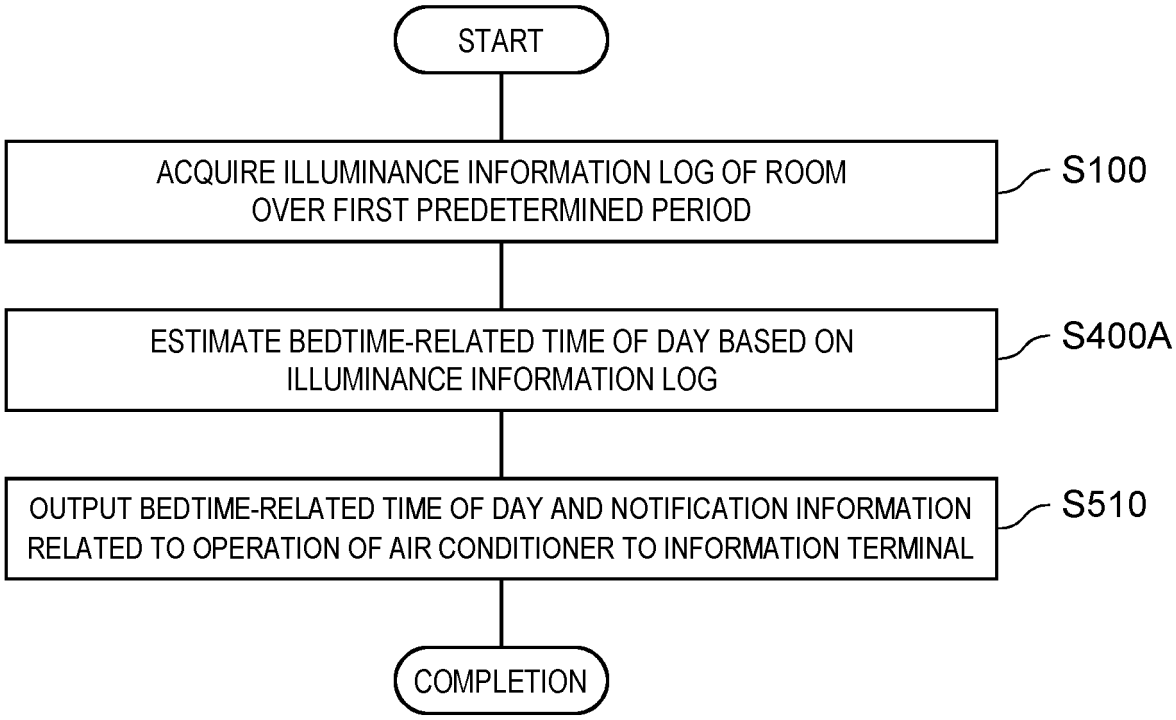
START
ACQUIRE ILLUMINANCE INFORMATION LOG OF ROOM OVER FIRST PREDETERMINED PERIOD
S100
ESTIMATE BEDTIME-RELATED TIME OF DAY BASED ON ILLUMINANCE INFORMATION LOG
S400A
OUTPUT BEDTIME-RELATED TIME OF DAY AND NOTIFICATION INFORMATION RELATED TO OPERATION OF AIR CONDITIONER TO INFORMATION TERMINAL
S510
COMPLETION

FIG. 4A

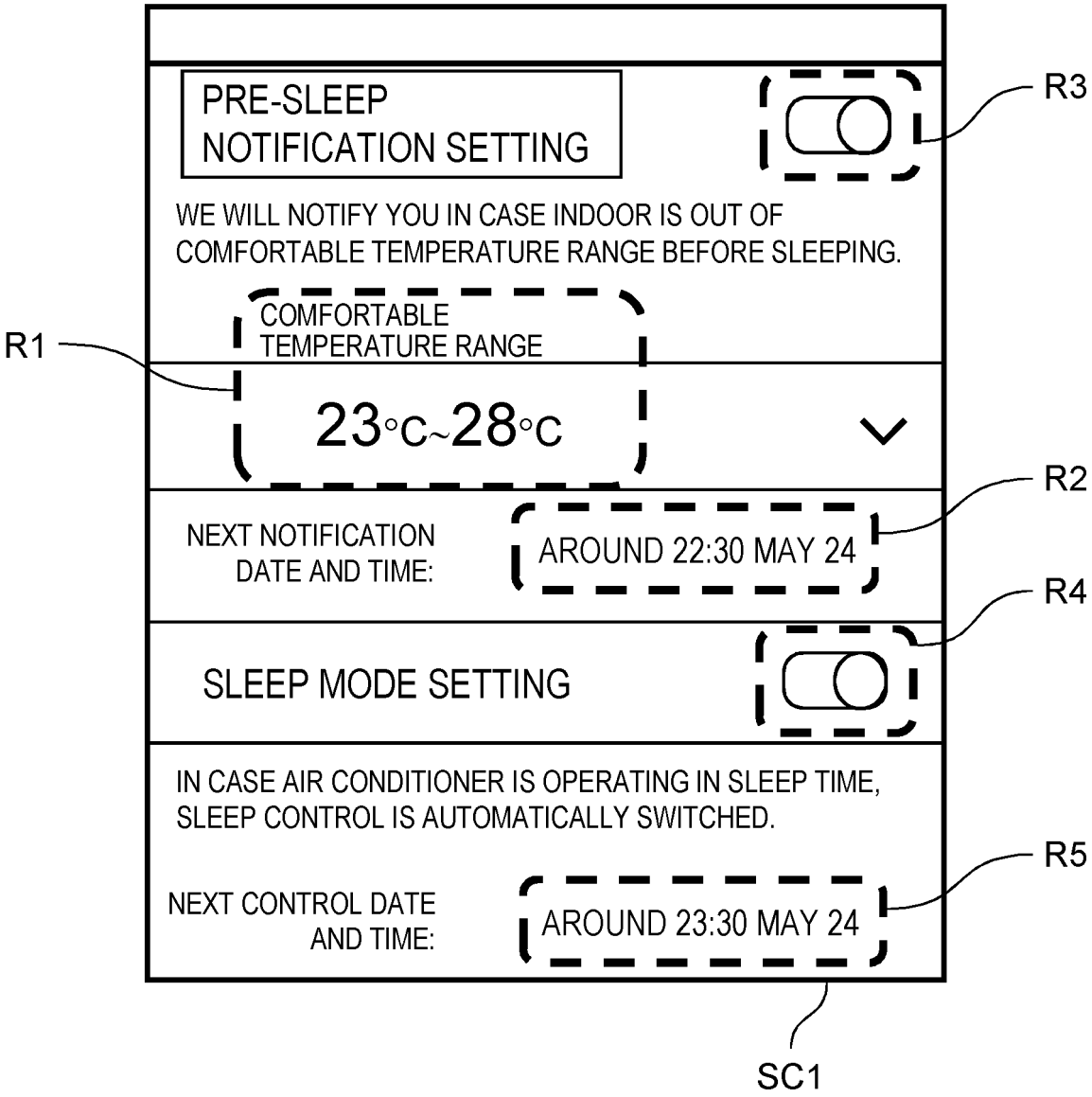
PRE-SLEEP
NOTIFICATION SETTING
R3
WE WILL NOTIFY YOU IN CASE INDOOR IS OUT OF
COMFORTABLE TEMPERATURE RANGE BEFORE SLEEPING.
R1
COMFORTABLE
TEMPERATURE RANGE
23°C~28°C
R2
NEXT NOTIFICATION
DATE AND TIME:
AROUND 22:30 MAY 24
R4
SLEEP MODE SETTING
IN CASE AIR CONDITIONER IS OPERATING IN SLEEP TIME,
SLEEP CONTROL IS AUTOMATICALLY SWITCHED.
R5
NEXT CONTROL DATE
AND TIME:
AROUND 23:30 MAY 24
SC1

FIG. 4B

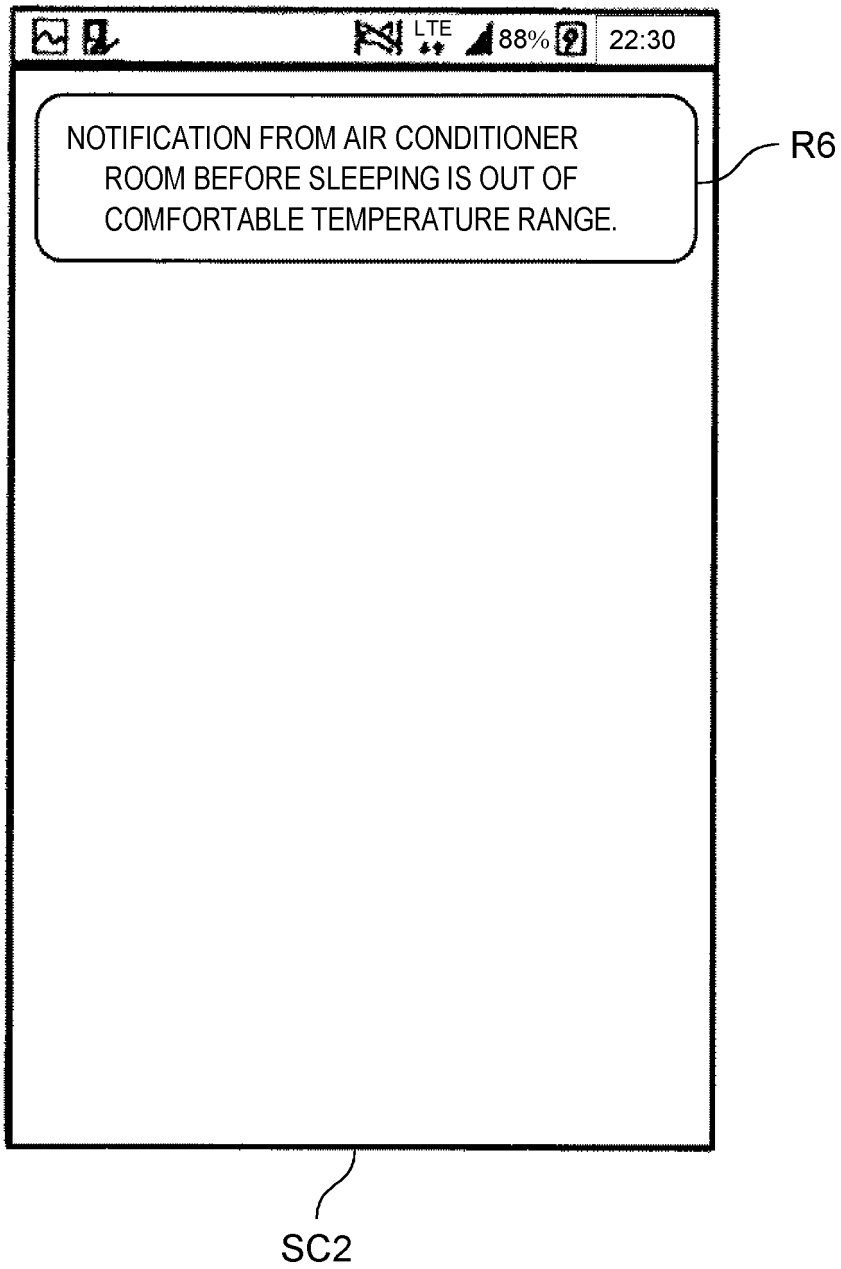
LTE
88%
22:30
NOTIFICATION FROM AIR CONDITIONER ROOM BEFORE SLEEPING IS OUT OF COMFORTABLE TEMPERATURE RANGE.
R6
SC2

FIG. 5

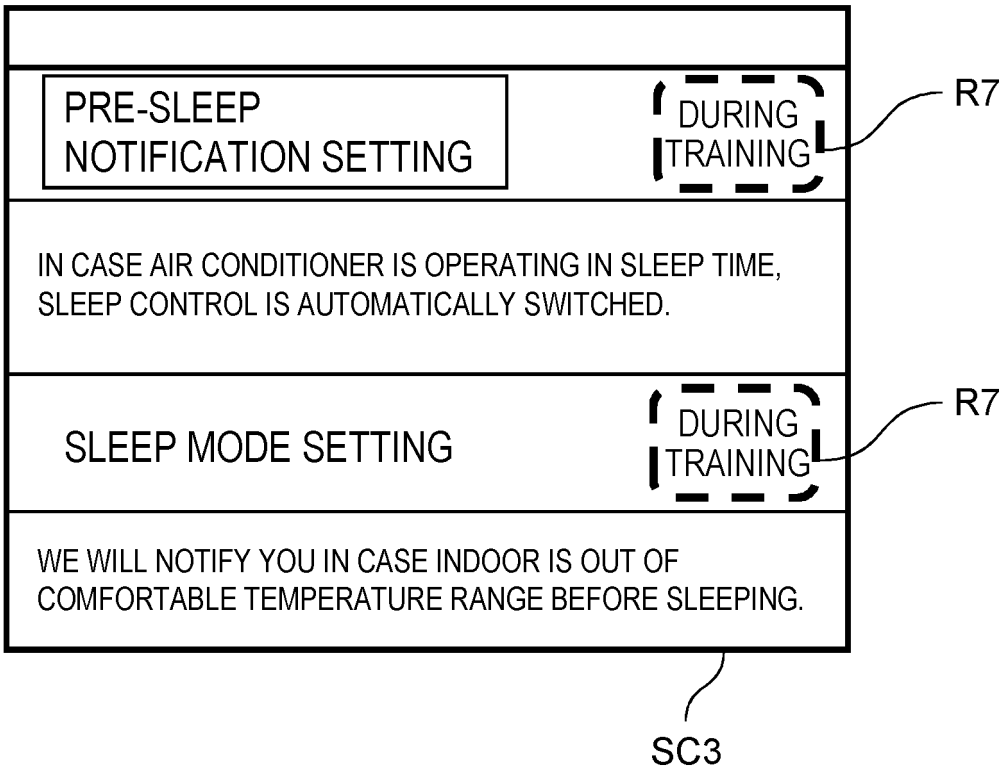
PRE-SLEEP
NOTIFICATION SETTING
DURING
TRAINING
R7
IN CASE AIR CONDITIONER IS OPERATING IN SLEEP TIME,
SLEEP CONTROL IS AUTOMATICALLY SWITCHED.
SLEEP MODE SETTING
DURING
TRAINING
R7
WE WILL NOTIFY YOU IN CASE INDOOR IS OUT OF
COMFORTABLE TEMPERATURE RANGE BEFORE SLEEPING.
SC3

FIG. 6

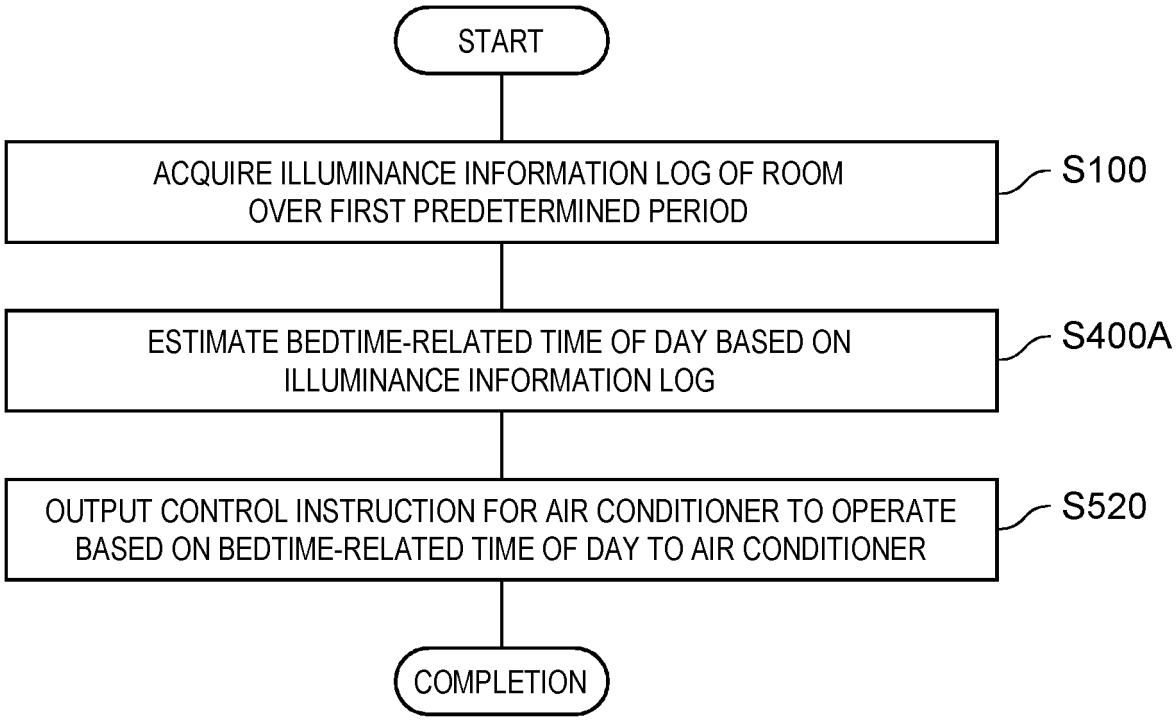
START
ACQUIRE ILLUMINANCE INFORMATION LOG OF ROOM OVER FIRST PREDETERMINED PERIOD
S100
ESTIMATE BEDTIME-RELATED TIME OF DAY BASED ON ILLUMINANCE INFORMATION LOG
S400A
OUTPUT CONTROL INSTRUCTION FOR AIR CONDITIONER TO OPERATE BASED ON BEDTIME-RELATED TIME OF DAY TO AIR CONDITIONER
S520
COMPLETION

FIG. 7

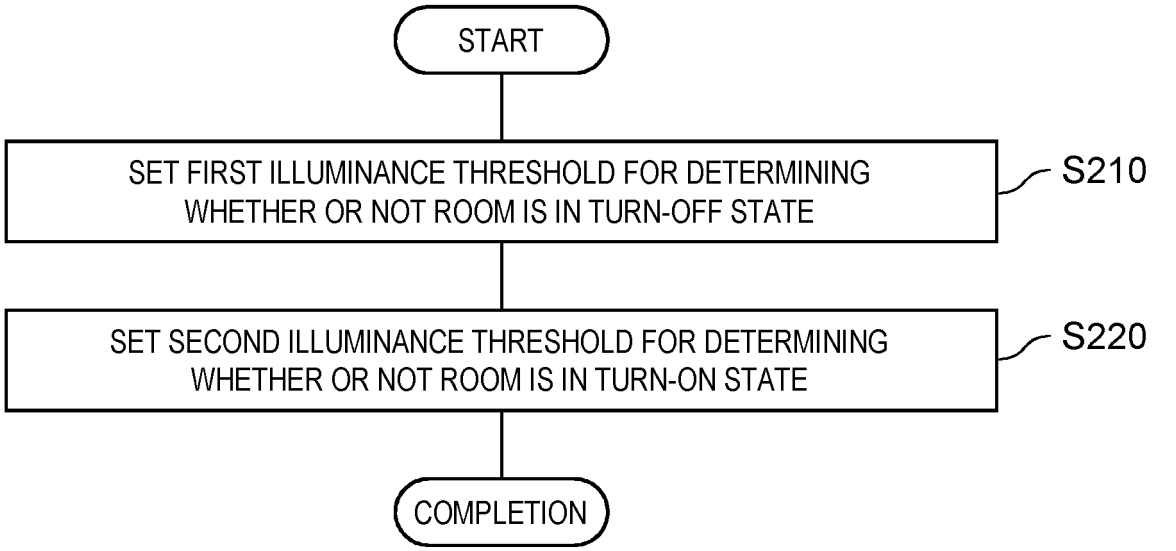
START
SET FIRST ILLUMINANCE THRESHOLD FOR DETERMINING WHETHER OR NOT ROOM IS IN TURN-OFF STATE
S210
SET SECOND ILLUMINANCE THRESHOLD FOR DETERMINING WHETHER OR NOT ROOM IS IN TURN-ON STATE
S220
COMPLETION

FIG. 8

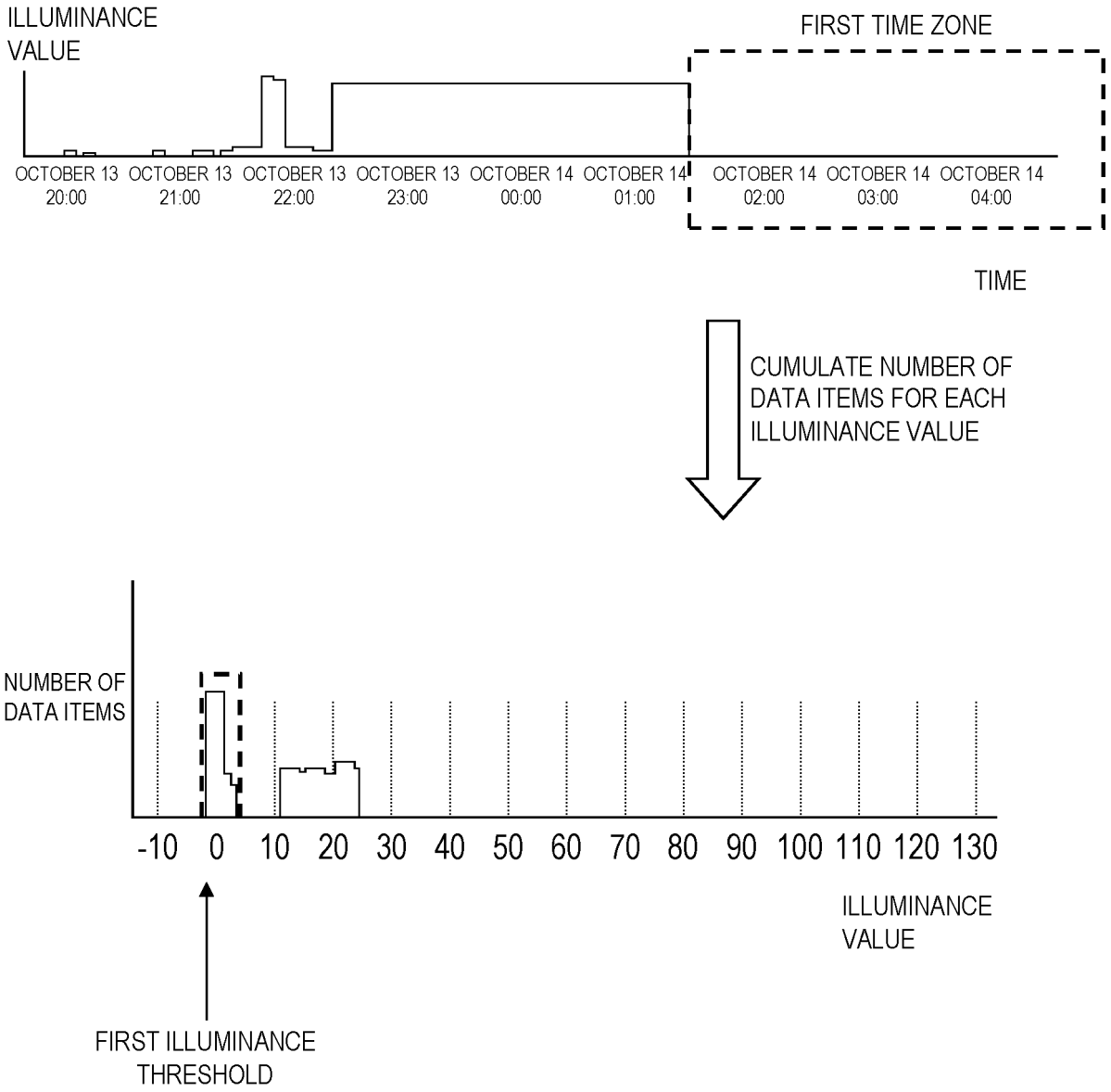
ILLUMINANCE VALUE
FIRST TIME ZONE
OCTOBER 13 20:00
OCTOBER 13 21:00
OCTOBER 13 22:00
OCTOBER 13 23:00
OCTOBER 14 00:00
OCTOBER 14 01:00
OCTOBER 14 02:00
OCTOBER 14 03:00
OCTOBER 14 04:00
TIME
CUMULATE NUMBER OF DATA ITEMS FOR EACH ILLUMINANCE VALUE
NUMBER OF DATA ITEMS
-10 0 10 20 30 40 50 60 70 80 90 100 110 120 130
ILLUMINANCE VALUE
FIRST ILLUMINANCE THRESHOLD

FIG. 9

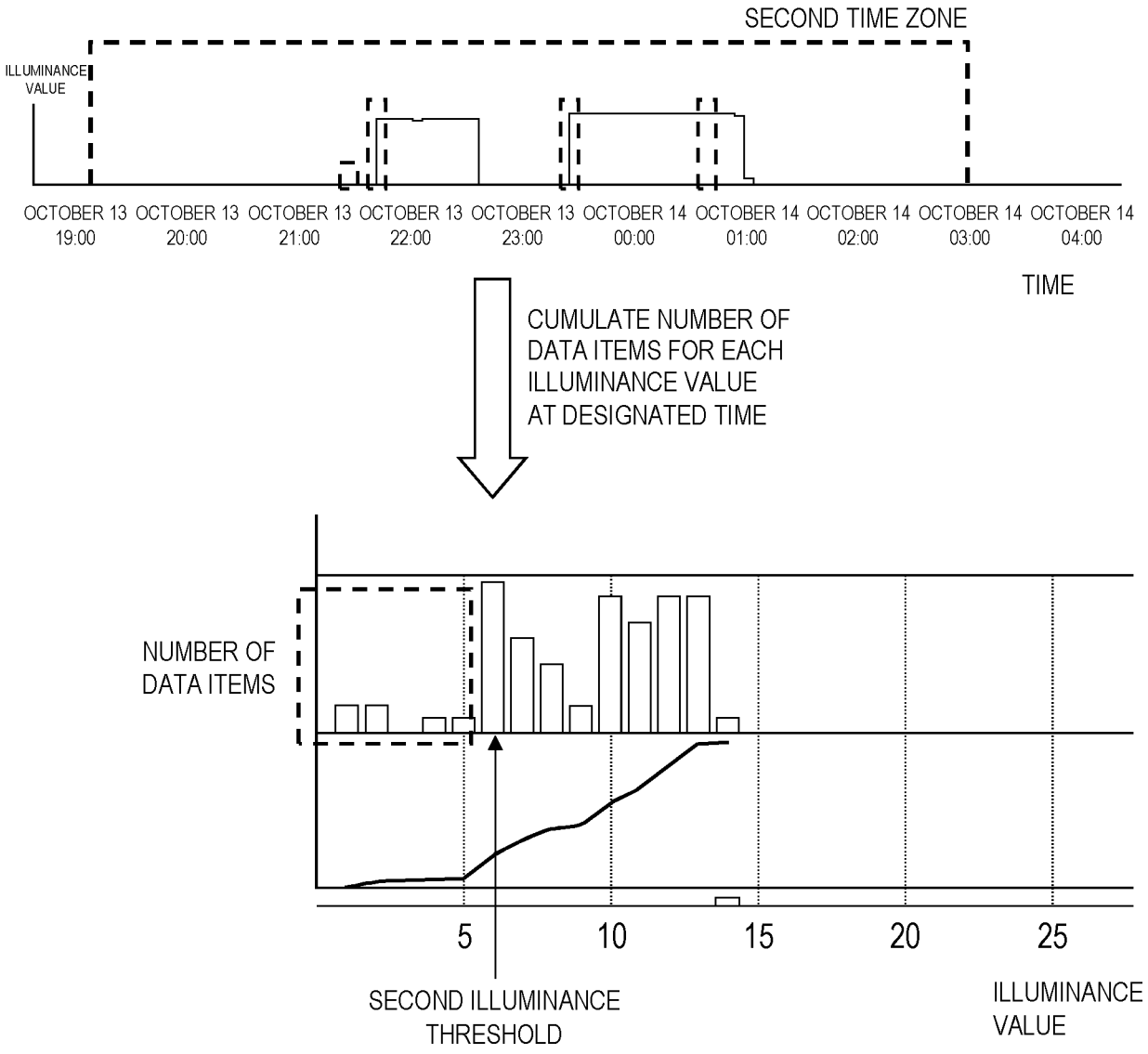
SECOND TIME ZONE
ILLUMINANCE VALUE
OCTOBER 13 19:00
OCTOBER 13 20:00
OCTOBER 13 21:00
OCTOBER 13 22:00
OCTOBER 13 23:00
OCTOBER 14 00:00
OCTOBER 14 01:00
OCTOBER 14 02:00
OCTOBER 14 03:00
OCTOBER 14 04:00
TIME
CUMULATE NUMBER OF DATA ITEMS FOR EACH ILLUMINANCE VALUE AT DESIGNATED TIME
NUMBER OF DATA ITEMS
5
10
15
20
25
SECOND ILLUMINANCE THRESHOLD
ILLUMINANCE VALUE

FIG. 10

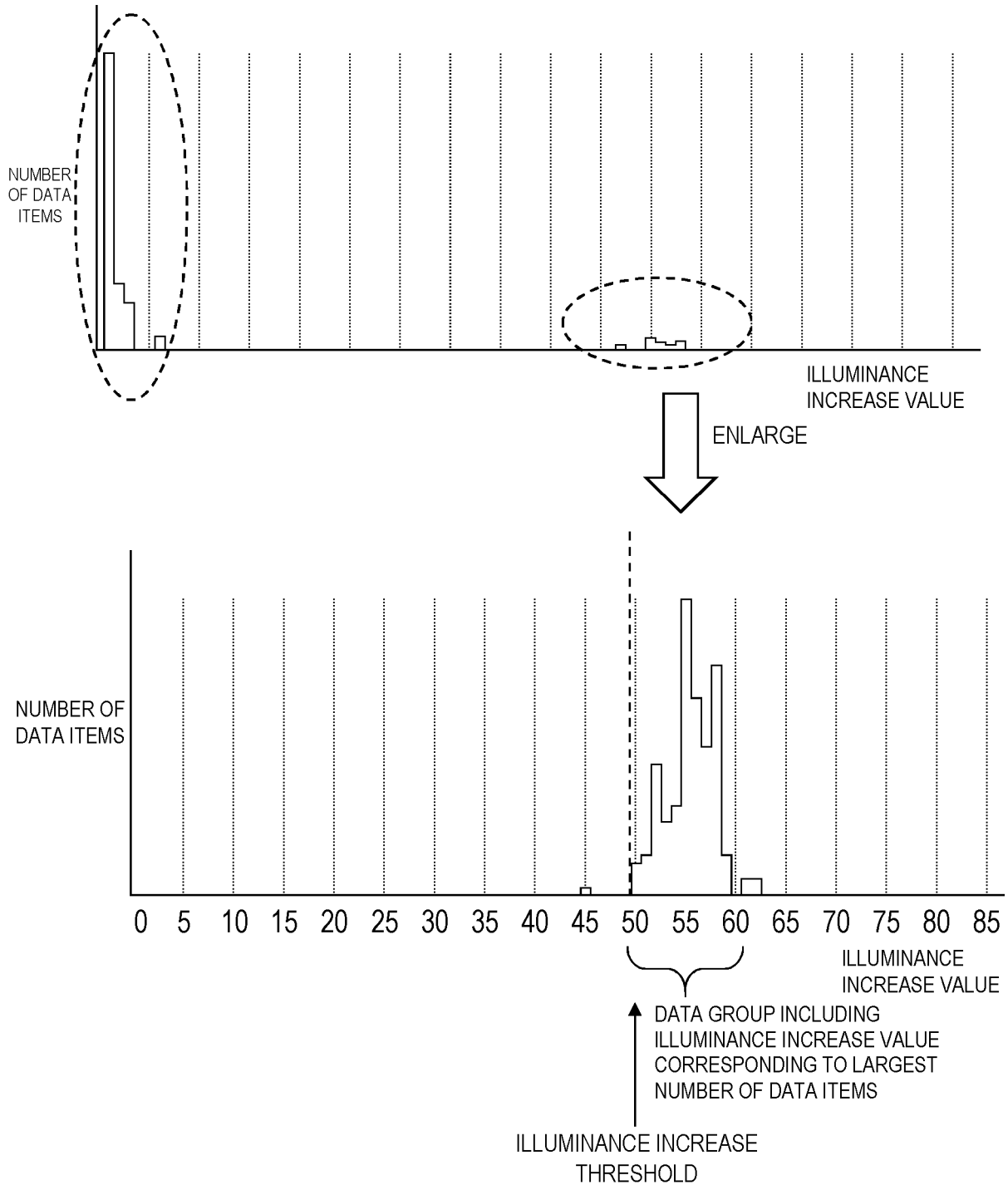
NUMBER OF DATA ITEMS
ILLUMINANCE INCREASE VALUE
ENLARGE
NUMBER OF DATA ITEMS
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
ILLUMINANCE INCREASE VALUE
DATA GROUP INCLUDING ILLUMINANCE INCREASE VALUE CORRESPONDING TO LARGEST NUMBER OF DATA ITEMS
ILLUMINANCE INCREASE THRESHOLD

FIG. 11

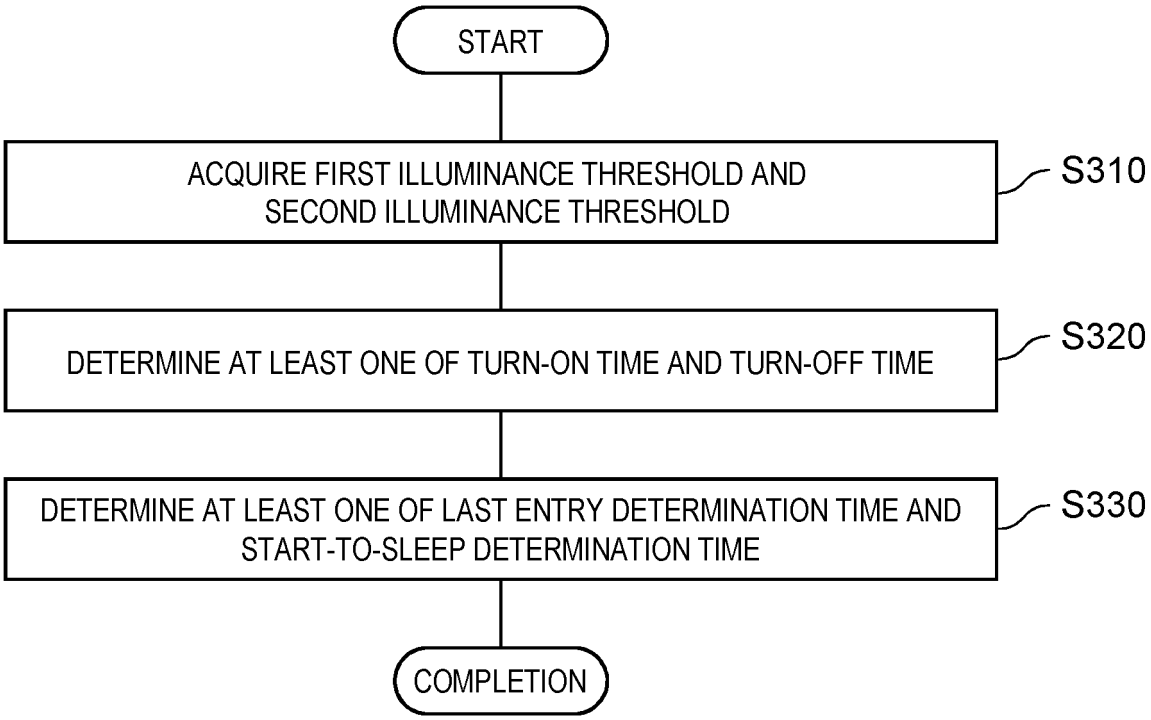
START
ACQUIRE FIRST ILLUMINANCE THRESHOLD AND SECOND ILLUMINANCE THRESHOLD
S310
DETERMINE AT LEAST ONE OF TURN-ON TIME AND TURN-OFF TIME
S320
DETERMINE AT LEAST ONE OF LAST ENTRY DETERMINATION TIME AND START-TO-SLEEP DETERMINATION TIME
S330
COMPLETION

FIG. 12

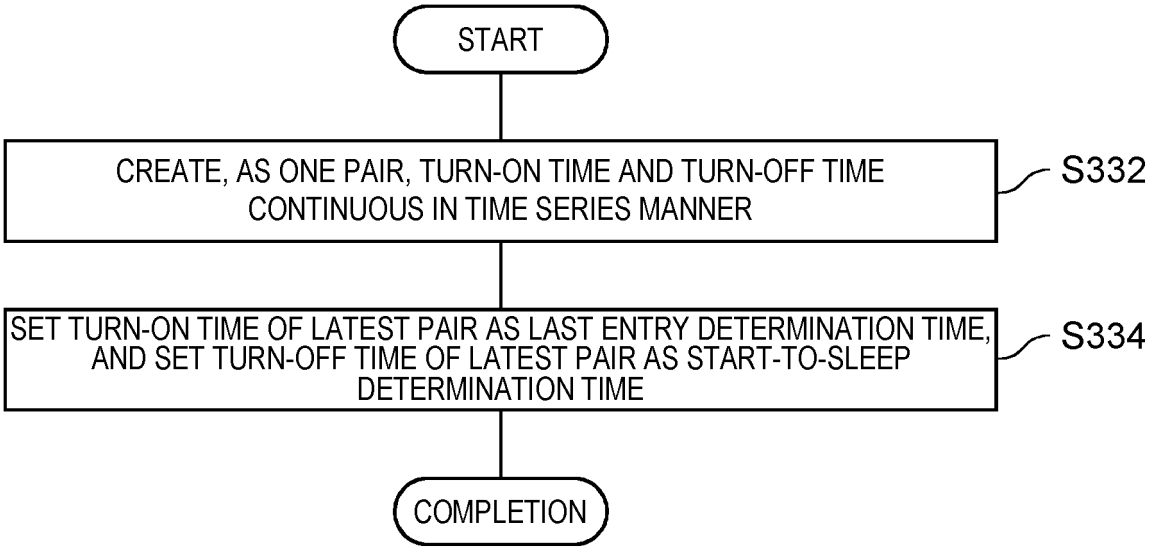
START
CREATE, AS ONE PAIR, TURN-ON TIME AND TURN-OFF TIME CONTINUOUS IN TIME SERIES MANNER
S332
SET TURN-ON TIME OF LATEST PAIR AS LAST ENTRY DETERMINATION TIME, AND SET TURN-OFF TIME OF LATEST PAIR AS START-TO-SLEEP DETERMINATION TIME
S334
COMPLETION

FIG. 13A

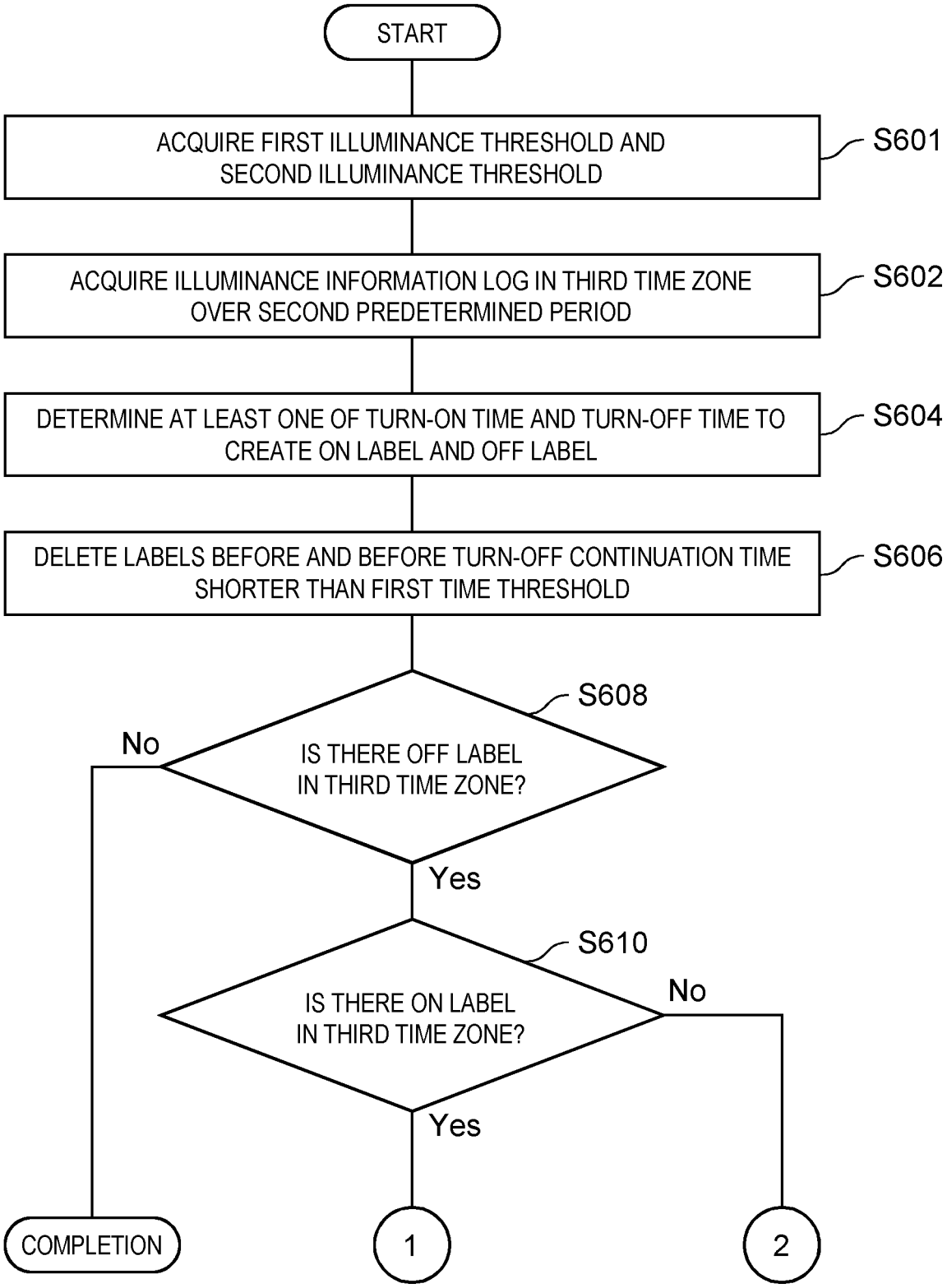
START
ACQUIRE FIRST ILLUMINANCE THRESHOLD AND SECOND ILLUMINANCE THRESHOLD
S601
ACQUIRE ILLUMINANCE INFORMATION LOG IN THIRD TIME ZONE OVER SECOND PREDETERMINED PERIOD
S602
DETERMINE AT LEAST ONE OF TURN-ON TIME AND TURN-OFF TIME TO CREATE ON LABEL AND OFF LABEL
S604
DELETE LABELS BEFORE AND BEFORE TURN-OFF CONTINUATION TIME SHORTER THAN FIRST TIME THRESHOLD
S606
S608
IS THERE OFF LABEL IN THIRD TIME ZONE?
No
Yes
S610
IS THERE ON LABEL IN THIRD TIME ZONE?
No
Yes
COMPLETION
1
2

FIG. 13B

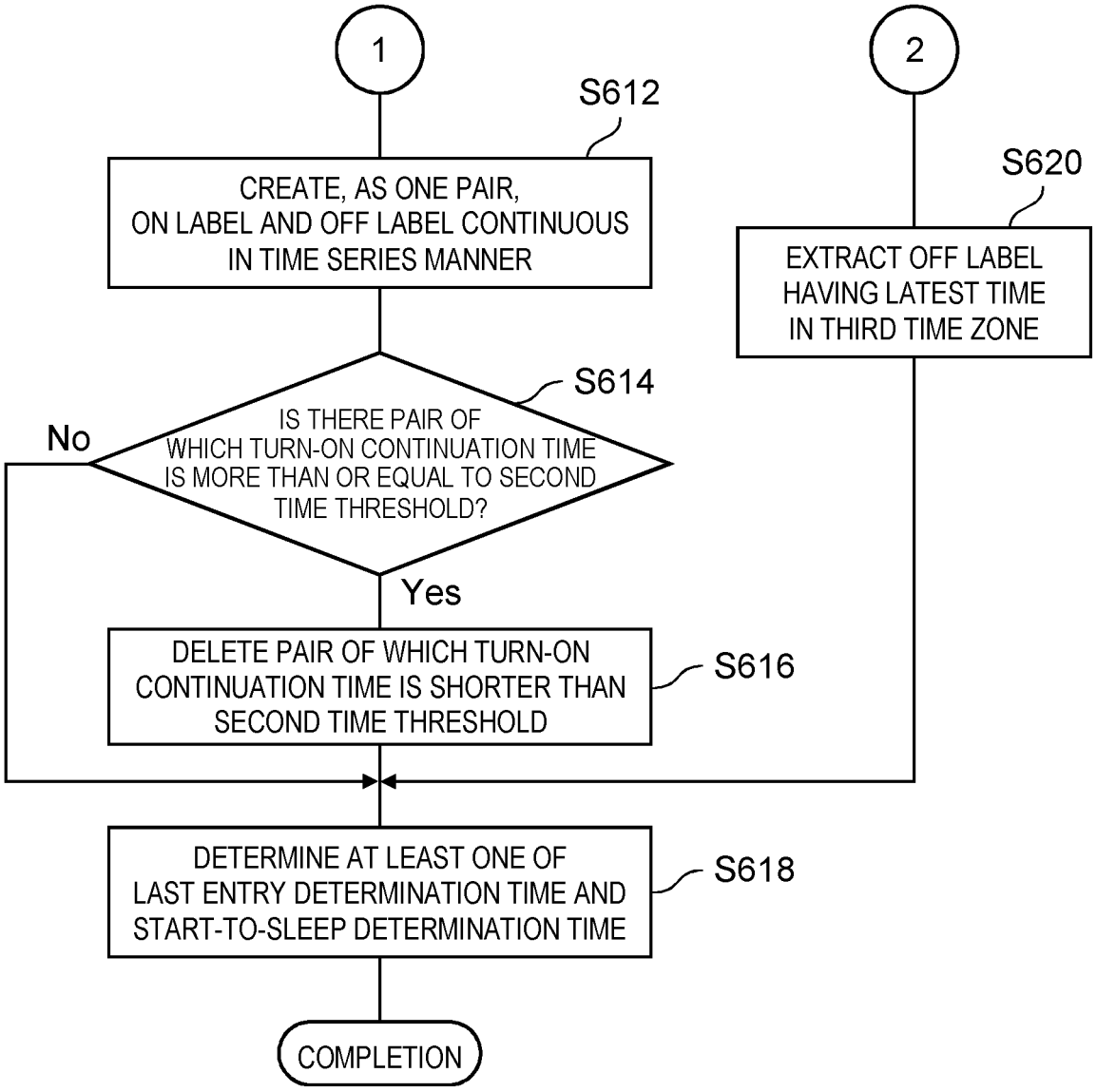
1
2
S612
CREATE, AS ONE PAIR, ON LABEL AND OFF LABEL CONTINUOUS IN TIME SERIES MANNER
S620
EXTRACT OFF LABEL HAVING LATEST TIME IN THIRD TIME ZONE
S614
IS THERE PAIR OF WHICH TURN-ON CONTINUATION TIME IS MORE THAN OR EQUAL TO SECOND TIME THRESHOLD?
No
Yes
DELETE PAIR OF WHICH TURN-ON CONTINUATION TIME IS SHORTER THAN SECOND TIME THRESHOLD
S616
DETERMINE AT LEAST ONE OF LAST ENTRY DETERMINATION TIME AND START-TO-SLEEP DETERMINATION TIME
S618
COMPLETION

FIG. 14A

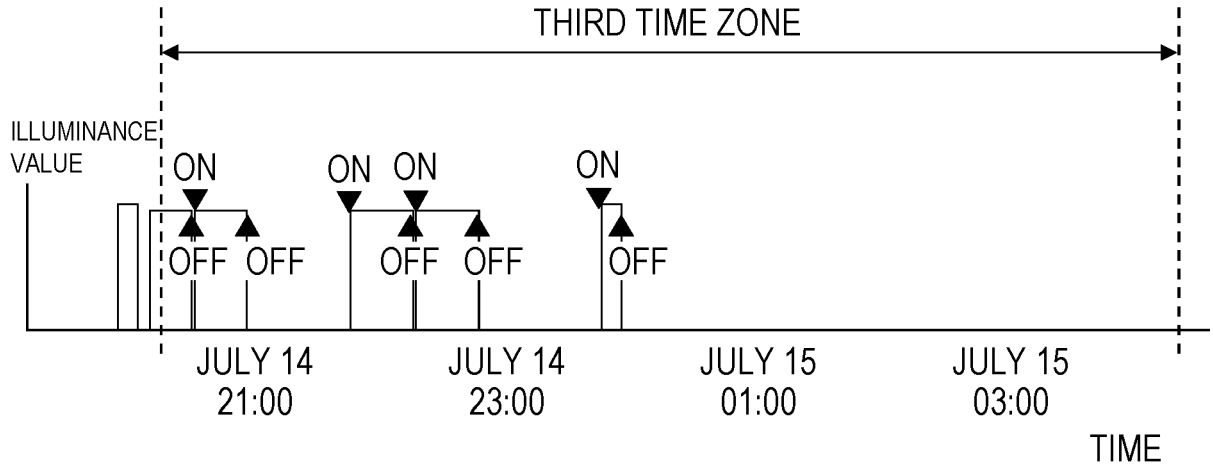

FIG. 14B

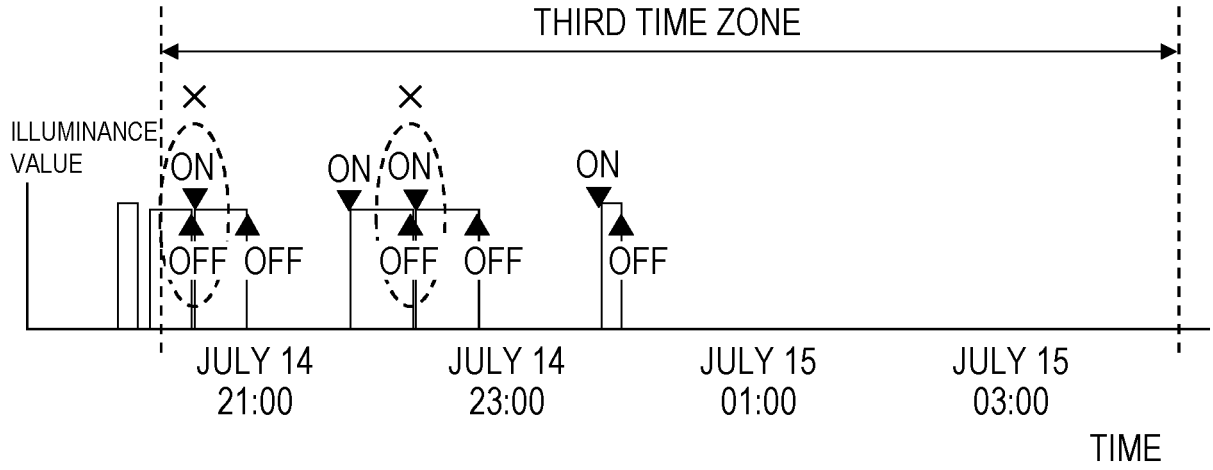

FIG. 14C

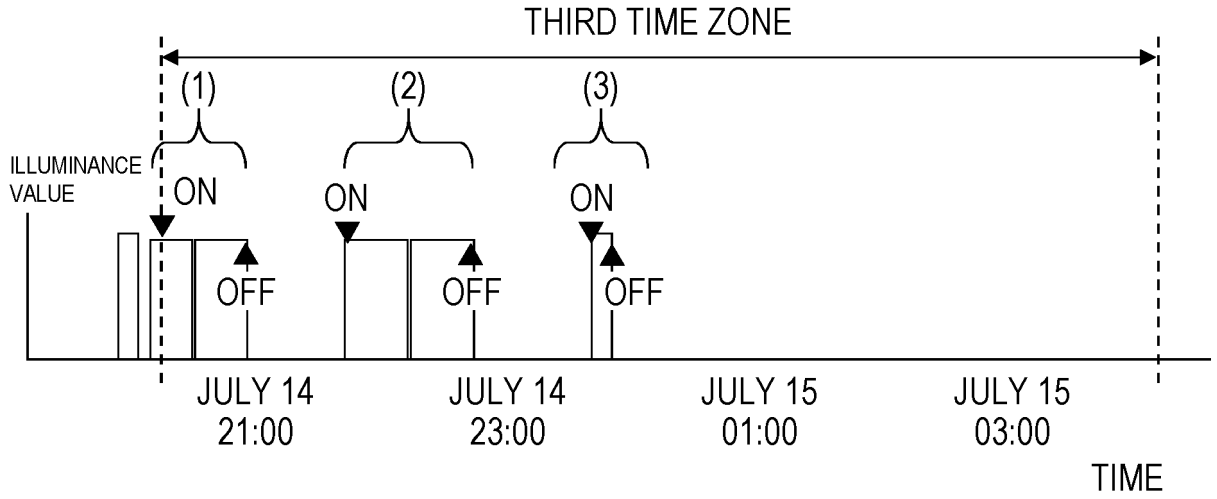

FIG. 14D

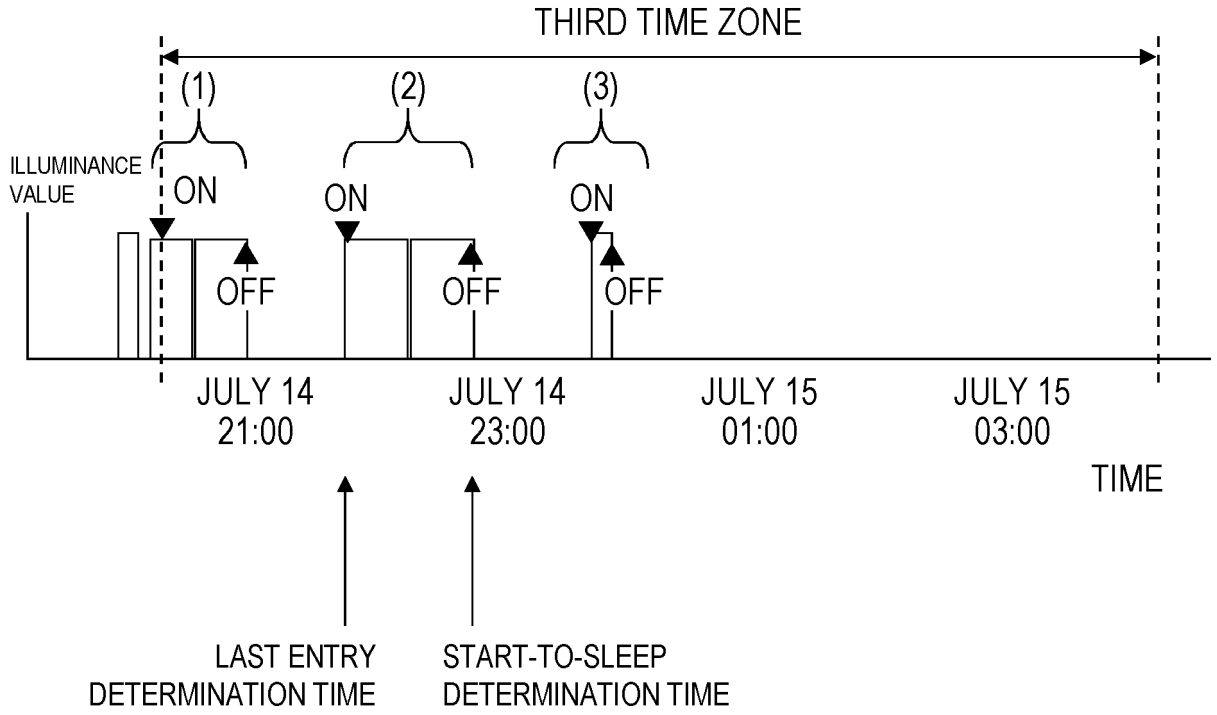

FIG. 15

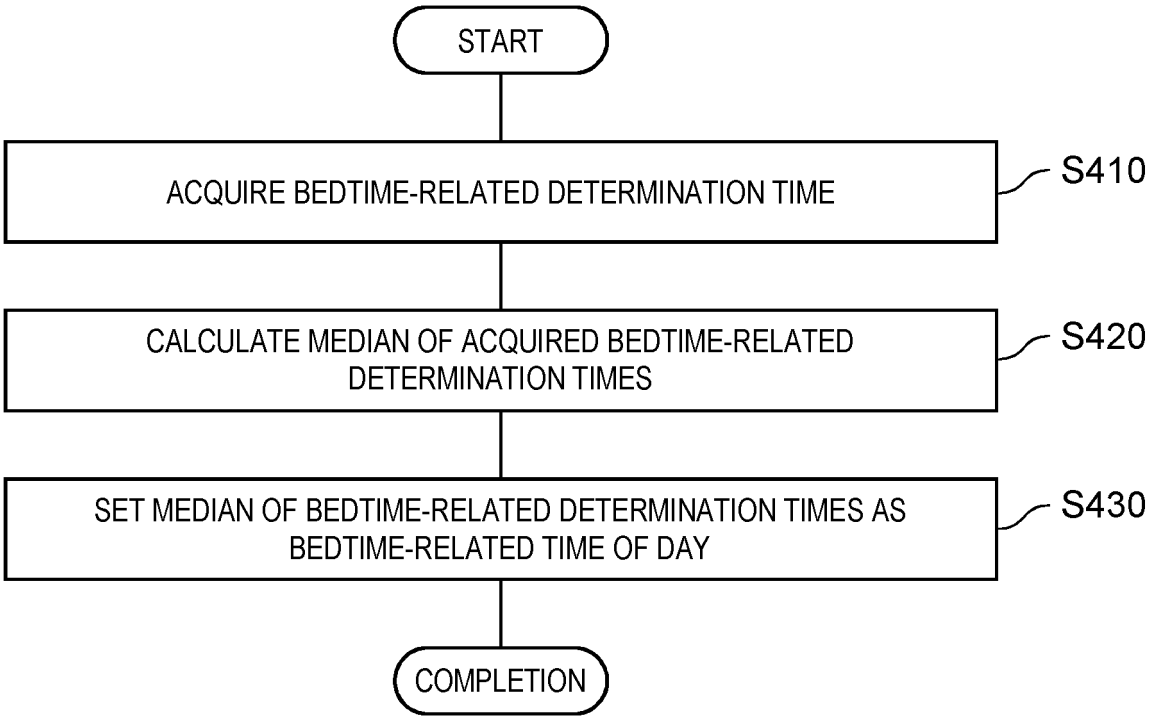
START
ACQUIRE BEDTIME-RELATED DETERMINATION TIME
S410
CALCULATE MEDIAN OF ACQUIRED BEDTIME-RELATED DETERMINATION TIMES
S420
SET MEDIAN OF BEDTIME-RELATED DETERMINATION TIMES AS BEDTIME-RELATED TIME OF DAY
S430
COMPLETION

FIG. 16

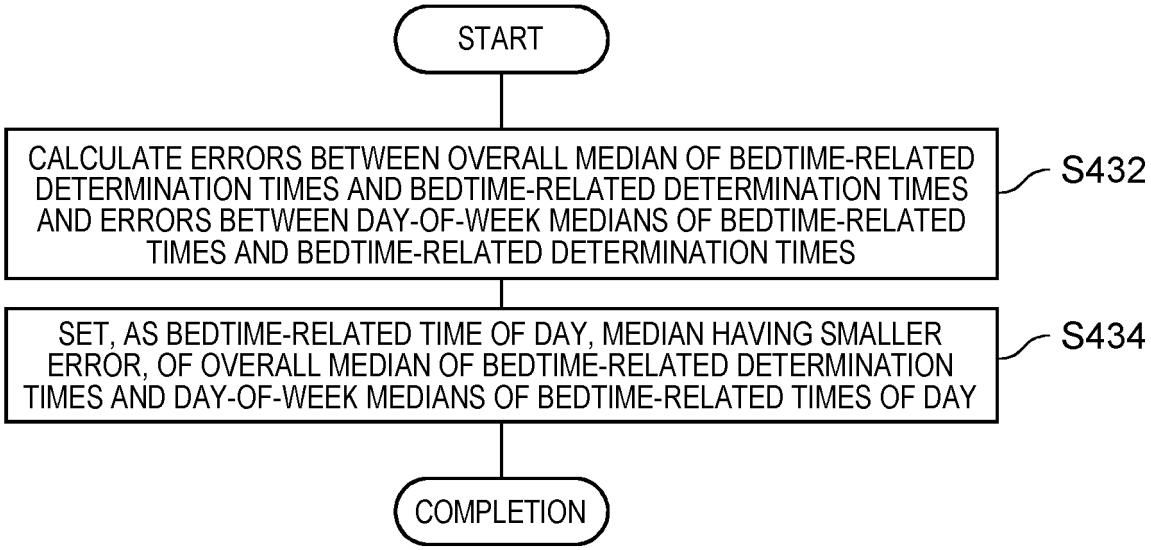
START
CALCULATE ERRORS BETWEEN OVERALL MEDIAN OF BEDTIME-RELATED DETERMINATION TIMES AND BEDTIME-RELATED DETERMINATION TIMES AND ERRORS BETWEEN DAY-OF-WEEK MEDIANS OF BEDTIME-RELATED TIMES AND BEDTIME-RELATED DETERMINATION TIMES
S432
SET, AS BEDTIME-RELATED TIME OF DAY, MEDIAN HAVING SMALLER ERROR, OF OVERALL MEDIAN OF BEDTIME-RELATED DETERMINATION TIMES AND DAY-OF-WEEK MEDIANS OF BEDTIME-RELATED TIMES OF DAY
S434
COMPLETION

FIG. 17

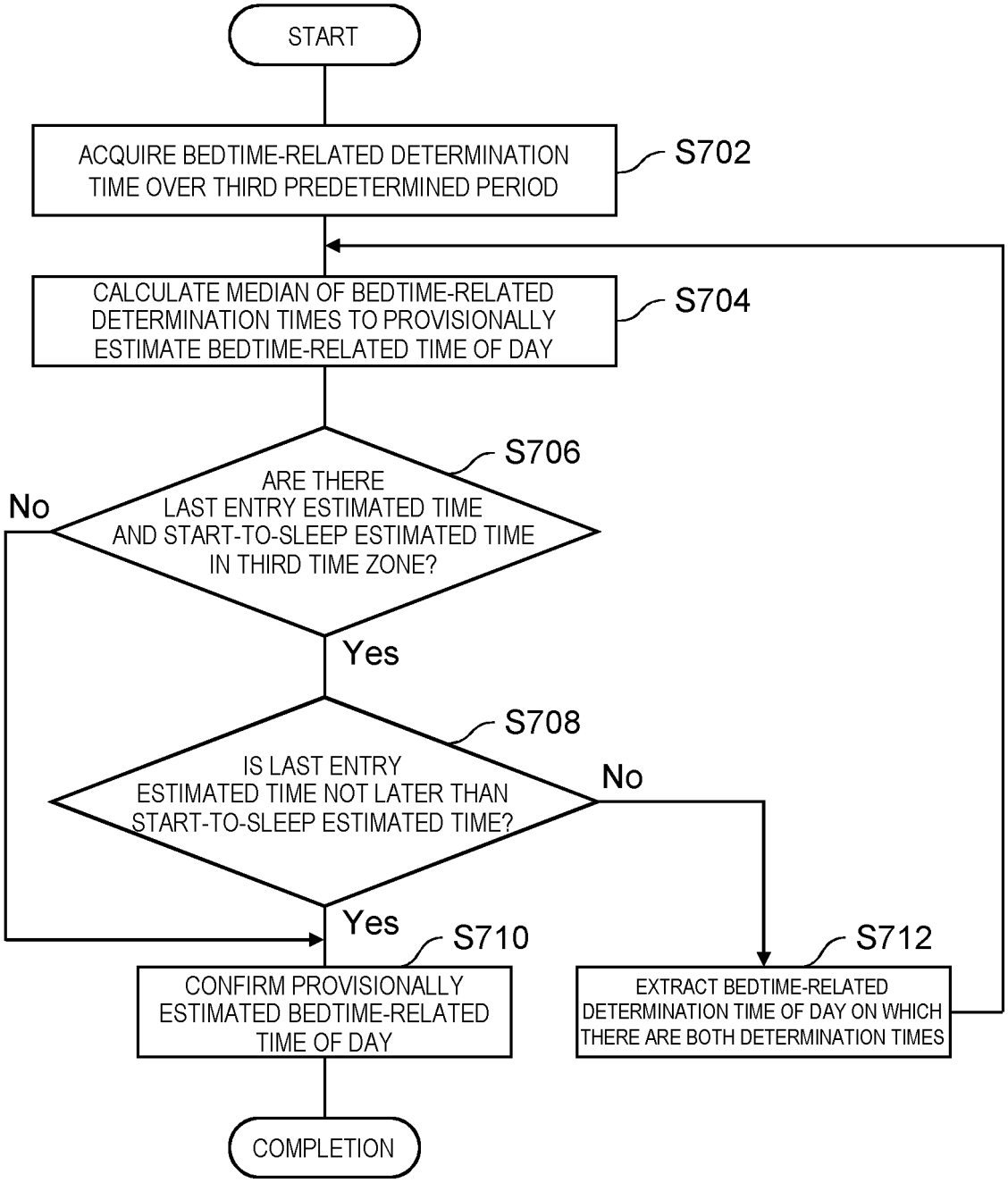
START
ACQUIRE BEDTIME-RELATED DETERMINATION TIME OVER THIRD PREDETERMINED PERIOD
S702
CALCULATE MEDIAN OF BEDTIME-RELATED DETERMINATION TIMES TO PROVISIONALLY ESTIMATE BEDTIME-RELATED TIME OF DAY
S704
S706
ARE THERE LAST ENTRY ESTIMATED TIME AND START-TO-SLEEP ESTIMATED TIME IN THIRD TIME ZONE?
No
Yes
S708
IS LAST ENTRY ESTIMATED TIME NOT LATER THAN START-TO-SLEEP ESTIMATED TIME?
No
Yes
S710
CONFIRM PROVISIONALLY ESTIMATED BEDTIME-RELATED TIME OF DAY
S712
EXTRACT BEDTIME-RELATED DETERMINATION TIME OF DAY ON WHICH THERE ARE BOTH DETERMINATION TIMES
COMPLETION

FIG. 18A

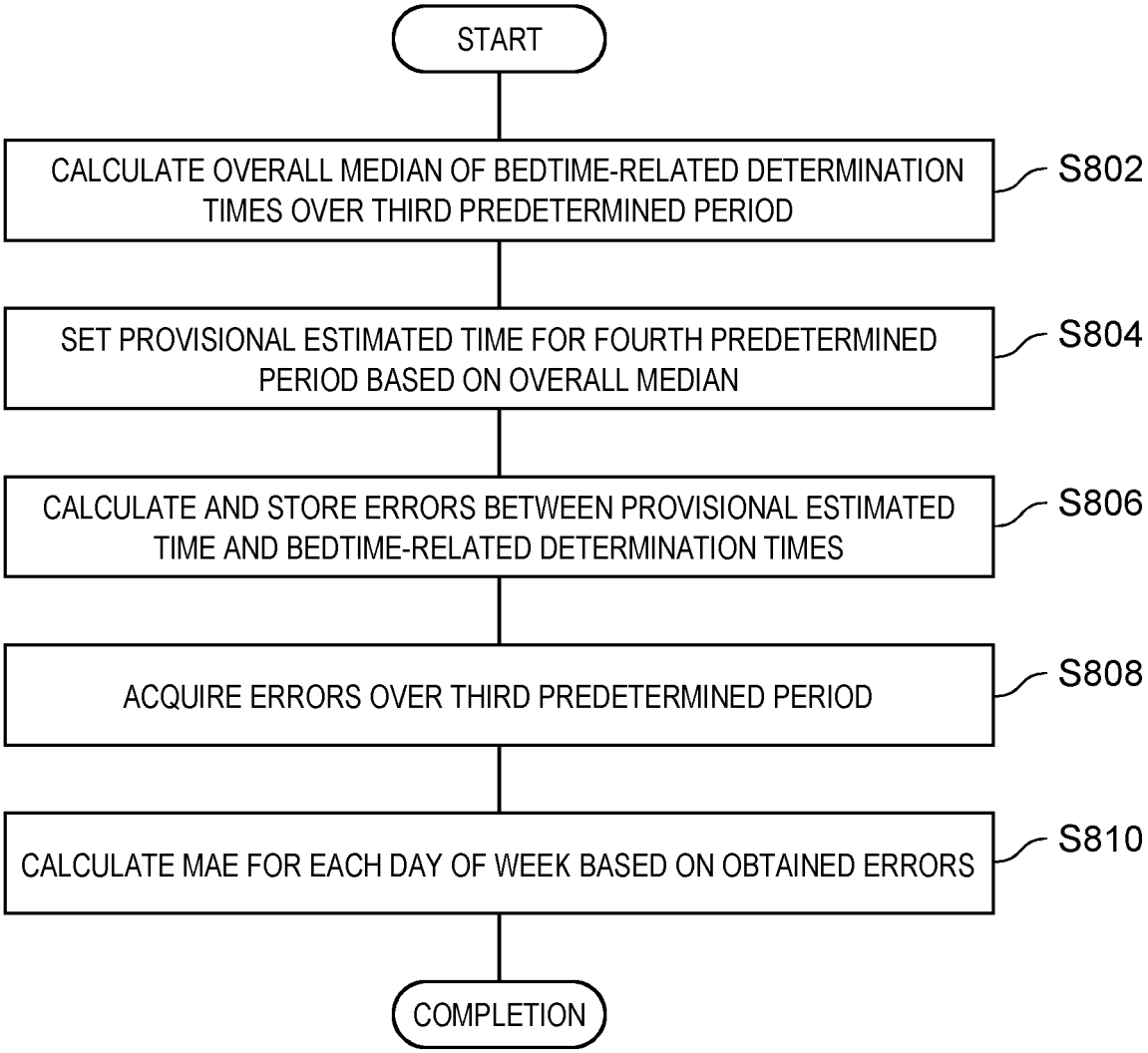
START
CALCULATE OVERALL MEDIAN OF BEDTIME-RELATED DETERMINATION TIMES OVER THIRD PREDETERMINED PERIOD
S802
SET PROVISIONAL ESTIMATED TIME FOR FOURTH PREDETERMINED PERIOD BASED ON OVERALL MEDIAN
S804
CALCULATE AND STORE ERRORS BETWEEN PROVISIONAL ESTIMATED TIME AND BEDTIME-RELATED DETERMINATION TIMES
S806
ACQUIRE ERRORS OVER THIRD PREDETERMINED PERIOD
S808
CALCULATE MAE FOR EACH DAY OF WEEK BASED ON OBTAINED ERRORS
S810
COMPLETION

FIG. 18B

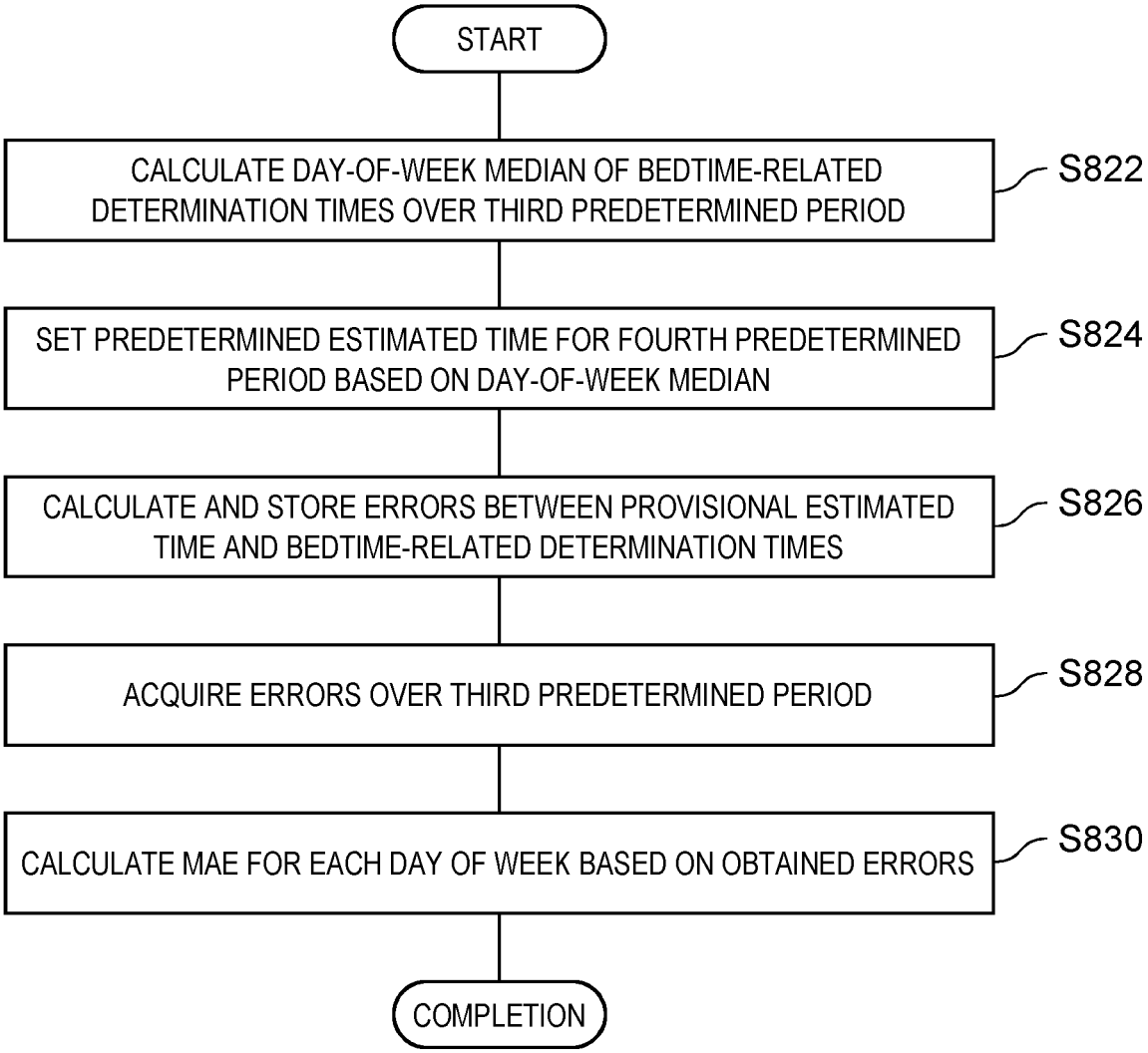
START
CALCULATE DAY-OF-WEEK MEDIAN OF BEDTIME-RELATED DETERMINATION TIMES OVER THIRD PREDETERMINED PERIOD
S822
SET PREDETERMINED ESTIMATED TIME FOR FOURTH PREDETERMINED PERIOD BASED ON DAY-OF-WEEK MEDIAN
S824
CALCULATE AND STORE ERRORS BETWEEN PROVISIONAL ESTIMATED TIME AND BEDTIME-RELATED DETERMINATION TIMES
S826
ACQUIRE ERRORS OVER THIRD PREDETERMINED PERIOD
S828
CALCULATE MAE FOR EACH DAY OF WEEK BASED ON OBTAINED ERRORS
S830
COMPLETION

FIG. 19A

(1) DETERMINATION RESULT FOR LATEST THIRD PREDETERMINED PERIOD

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
23:30	23:10	23:20	23:00	01:20	0:50	23:00
...	...	...	...	...	...	...

(2) PROVISIONAL ESTIMATED TIME FOR FOURTH PREDETERMINED PERIOD BASED ON OVERALL MEDIAN

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
23:00	23:00	23:00	23:00	23:00	23:00	23:00

(3) ERRORS OF OVERALL MEDIAN FOR LATEST FOURTH PREDETERMINED PERIOD

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
-30	-10	-20	0	-140	-110	0

(4) ERRORS OF OVERALL MEDIAN FOR THIRD PREDETERMINED PERIOD

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
-10	-30	-10	-10	-60	-50	10
...	...	...	...	...	...	...
-30	-10	-20	0	-140	-110	0

(5) MAE FOR EACH DAY OF WEEK

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
20	10	20	10	80	70	20

FIG. 19B

(6) DETERMINATION RESULT FOR LATEST THIRD PREDETERMINED PERIOD

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
23:30	23:10	23:20	23:00	01:20	0:50	23:00
...	...	...	...	...	...	...

(7) PROVISIONAL ESTIMATED TIME FOR FOURTH PREDETERMINED PERIOD BASED ON DAY-OF-WEEK MEDIAN

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
23:00	23:00	23:00	23:00	01:00	01:00	23:00

(8) ERRORS OF DAY-OF-WEEK MEDIANS FOR LATEST FOURTH PREDETERMINED PERIOD

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
-30	-10	-20	0	-20	10	0

(9) ERRORS OF DAY-OF-WEEK MEDIANS FOR THIRD PREDETERMINED PERIOD

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
-10	-30	-10	-10	-30	-20	10
...	...	...	...	...	...	...
-30	-10	-20	0	-20	10	0

(10) MAE FOR EACH DAY OF WEEK

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
20	10	20	10	20	10	20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/037548

A. CLASSIFICATION OF SUBJECT MATTER

F24F 11/62(2018.01)i; ***F24F 11/66***(2018.01)i; *F24F 110/10*(2018.01)n
FI: F24F11/66; F24F11/62; F24F110:10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F24F11/62; F24F11/66; F24F110/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 9-170797 A (SHARP CORP) 30 June 1997 (1997-06-30) paragraphs [0015]-[0031]	1, 3, 11, 13
A		2, 4-10, 12, 14-20
Y	JP 2021-50844 A (SHARP CORP) 01 April 2021 (2021-04-01) paragraphs [0007]-[0087]	1, 3, 11, 13

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 October 2022	**13 December 2022**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/037548

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 9-170797 A	30 June 1997	(Family: none)	
JP 2021-50844 A	01 April 2021	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 6338984 B **[0003]**