

DESCRIPTION

TITLE:

INFORMATION PROCESSING DEVICE, INFORMATION PROCESSING METHOD,
AND INFORMATION PROCESSING PROGRAM

Technical Field

[0001] The present invention relates to an information processing device, an information processing method, and an information processing program.

Related Art

[0002] Conventionally, there exists a technology for automatically changing a setting value of an air conditioner.

Prior-Art Documents

Patent Documents

[0003] [Patent Document 1] Japanese Patent Laid-open No. 2015-004480

[Patent Document 2] Japanese Patent Laid-open No. 2013-029272

SUMMARY OF THE INVENTION

Problems to Be Solved by the Invention

[0004] In the conventional technology, it may not always be possible to automatically operate an indoor temperature setting value considering energy consumption while ensuring user comfort. For example, in the conventional technology, there are cases where an infeasible setting value is set due to limitations of the environment or the air conditioner, and energy consumption is increased due to a decrease in operating efficiency of the air conditioner. There are many cases where a set value is actually uncomfortable for the user.

Every time the user feels uncomfortable, they have to perform temperature setting themselves, which places a heavy burden on the user. The problems that the present invention aims to solve include the above-mentioned problems.

[0005] The present invention has been made in view of the above, and an object thereof is to provide an information processing device, an information processing method, and an information processing program, in which an indoor temperature setting value is automatically operated considering energy consumption while ensuring user comfort.

Means for Solving the Problems

[0006] In order to solve the above-mentioned problems and achieve the object, an information processing device of the present invention includes: an acquisition module, acquiring sensor data and thermal sensation-related information; a calculation module, calculating a setting value candidate for indoor temperature based on the thermal sensation-related information acquired by the acquisition module; an estimation module, for each of the setting value candidate calculated by the calculation module, estimating, using the sensor data acquired by the acquisition module, an indoor environment and energy consumption in a case where air conditioning is controlled using the setting value candidate calculated by the calculation module as an indoor temperature setting value; and a selection module, selecting the setting value candidate for indoor temperature based on the indoor environment and the energy consumption estimated by the estimation module as well as an allowable range of thermal sensation included in the thermal sensation-related information acquired by the acquisition module.

Effects of the Invention

[0007] According to the present invention, it is possible to automatically operate an indoor temperature setting value considering energy consumption while ensuring user comfort.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 illustrates an example of a configuration of an information processing device according to an embodiment.

FIG. 2 is a flowchart illustrating an example of a flow of processing by an estimation module according to an embodiment.

FIG. 3 illustrates processing performed by the information processing device according to an embodiment.

FIG. 4 illustrates an example of processing performed by a selection module according to an embodiment.

FIG. 5 illustrates an example of processing performed by the selection module according to an embodiment.

FIG. 6 illustrates an example of an infeasible setting value according to an embodiment.

FIG. 7 is a flowchart illustrating an example of a flow of processing by the information processing device according to an embodiment.

FIG. 8 illustrates an example of a computer that executes an information processing program.

DESCRIPTION OF THE EMBODIMENTS

[0009] Hereinafter, an embodiment of an information processing device, an information processing method, and an information processing program according to the present application will be described in detail with reference to the drawings. The present invention is not limited to this embodiment. In the drawings, the same portions are denoted by the same reference numerals, and duplicate descriptions will be omitted as

appropriate. When “ $A^{\wedge}$ ” is written with respect to sign A, it is considered to be equivalent to “a sign with ‘ $\wedge$ ’ written directly above ‘A’”.

[0010] [Introduction]

Conventionally, air conditioning in an office building or the like has been controlled to keep the indoor temperature constant. For example, an air conditioner operates in accordance with a set temperature determined by a user or an administrator staying in an office. However, in the conventional technology, it may not always be possible to automatically operate an indoor temperature setting value considering energy consumption while ensuring user comfort. For example, in the conventional technology, there are cases where a set temperature cannot be realized due to factors such as a discrepancy between an actual temperature and the set temperature due to limitations of the environment or the air conditioner. If such an infeasible setting value is set, operating efficiency of the air conditioner is decreased, and energy consumption is increased instead.

[0011] There are many cases where a temperature set by automatic operation or a temperature set by the user themselves is uncomfortable for the user. In addition, if the user feels that the set temperature is uncomfortable, the user has to manually change the set temperature, which places a heavy burden on the user. Furthermore, every time the user performs an operation, their work is interrupted, which might lead to a decrease in work efficiency. Hence, in automating operation of the indoor temperature setting value, it is desirable to automatically change the indoor temperature setting value to ensure the comfort of an office occupant and reduce energy consumption.

[0012] Thus, in an information processing device 100 according to an embodiment, sensor data and thermal sensation-related information are acquired. Based on the acquired thermal sensation-related information, a setting value candidate for indoor temperature is calculated. For each setting value candidate calculated, an indoor environment and energy

consumption in a case where air conditioning is controlled using the setting value candidate as an indoor temperature setting value are estimated using the sensor data. Based on the estimated indoor environment, the estimated energy consumption and an allowable range of thermal sensation included in the thermal sensation-related information, the setting value candidate for indoor temperature is selected. Accordingly, in the information processing device 100, by using a result of simulation of an operation condition of the air conditioner, it is possible to automatically operate an indoor temperature setting value considering energy consumption while ensuring user comfort.

[0013] [Configuration of Information Processing Device]

Next, a configuration of the information processing device 100 is described with reference to FIG. 1. FIG. 1 illustrates an example of the configuration of the information processing device 100. As shown in FIG. 1, the information processing device 100 includes a communication module 110, a control module 120, and a storage module 130. These modules may be distributedly held in a plurality of devices. Processing of each module is described below.

[0014] The communication module 110 is realized by a network interface controller (NIC) or the like, and enables communication between the control module 120 and an external device via an electric communication line such as a local area network (LAN) or the Internet. For example, the communication module 110 enables communication between the control module 120 and an external device.

[0015] The storage module 130 is realized by a semiconductor memory element such as a random access memory (RAM) or a flash memory, or by a storage device such as a hard disk or an optical disk. Examples of information stored in the storage module 130 include sensor data, thermal sensation-related information, setting value candidates, simulation models, setting values, and other information necessary for automatic operation of setting

values. Here, the sensor data includes information such as outdoor air condition, indoor environment, and air conditioner state. The outdoor air condition includes information such as outdoor air temperature, outdoor air humidity, and solar radiation condition. The indoor environment includes information such as indoor temperature, indoor humidity, and indoor CO₂ concentration. The thermal sensation-related information is information on predicted mean vote (PMV) used as an index of thermal sensation felt by humans, and includes information such as an allowable range ($PMV = -0.5$ to $+0.5$) of thermal sensation and an optimal value ($PMV = 0$) of thermal sensation. The information stored in the storage module 130 is not limited to the examples described above.

[0016] The control module 120 is realized using a central processing unit (CPU), a network processor (NP) or a field programmable gate array (FPGA), and executes a processing program stored in a memory. As shown in FIG. 1, the control module 120 includes an acquisition module 121, a computation module 122, a calculation module 123, an estimation module 124, a determination module 125, and a selection module 126. Each module included in the control module 120 will be described below.

[0017] The acquisition module 121 acquires the sensor data and the thermal sensation-related information. For example, the acquisition module 121 acquires, as the sensor data, information such as outdoor air condition, indoor environment, and air conditioner state, from an external system such as a building automation system (BAS). For example, the acquisition module 121 acquires, as the thermal sensation-related information, information such as an allowable range of thermal sensation and an optimal value of thermal sensation, from an external system. The acquisition module 121 may also acquire the thermal sensation-related information from the storage module 130.

[0018] The computation module 122 computes an optimal value of indoor temperature from the optimal value of thermal sensation included in the thermal sensation-related

information acquired by the acquisition module 121. For example, the computation module 122 computes the optimal value of indoor temperature from the optimal value of thermal sensation using a function that calculates the thermal sensation from a condition such as the indoor temperature. More specifically, the computation module 122 computes the optimal value of indoor temperature from the optimal value of thermal sensation using Expressions 1 and 2 below. Here, PMV stands for thermal sensation. PMV_{opt} stands for optimal value of thermal sensation. t stands for temperature. t_{opt} stands for optimal value of indoor temperature. F stands for the function that calculates the thermal sensation from a condition such as the indoor temperature.

[0019] $PMV = F(t) \quad \cdots (1)$

[0020] $t_{opt} = F^{-1}(PMV_{opt}) \quad \cdots (2)$

[0021] The calculation module 123 calculates a setting value candidate for indoor temperature based on the thermal sensation-related information acquired by the acquisition module 121. For example, the calculation module 123 calculates, as the setting value candidate for indoor temperature, a temperature corresponding to the allowable range of thermal sensation included in the thermal sensation-related information acquired by the acquisition module 121. For example, the calculation module 123 calculates the temperature corresponding to the allowable range of thermal sensation as the setting value candidate for indoor temperature using Expression 1. More specifically, the calculation module 123 converts a lower limit ($PMV = -0.5$) of the allowable range of thermal sensation and an upper limit ($PMV = +0.5$) of the allowable range of thermal sensation respectively into indoor temperatures using Expression 1, and calculates a temperature within a temperature range after conversion as the setting value candidate for indoor temperature. When converting thermal sensation into temperature or converting temperature into thermal

sensation using Expressions 1 and 2, a predetermined value may be used as a control value for elements other than temperature.

[0022] The calculation module 123 adds or subtracts a predetermined value to or from the optimal value of indoor temperature computed by the computation module 122, and calculates the setting value candidate for indoor temperature. For example, the calculation module 123 calculates, as the setting value candidate for indoor temperature, a value within a range from a value obtained by adding the predetermined value to the optimal value of indoor temperature computed by the computation module 122 to a value obtained by subtracting the predetermined value from the optimal value of indoor temperature. More specifically, the calculation module 123 calculates, as the setting value candidate for indoor temperature, a value between 22 °C and 24 °C being a range of values obtained by adding or subtracting a predetermined value 1.0 to or from the optimal value of indoor temperature of 23 °C computed by the computation module 122. The predetermined value can be any value depending on the purpose. The predetermined value is not limited to one, and a plurality of predetermined values may be used. That is, for example, the calculation module 123 may calculate, as the setting value candidate, values alone obtained by adding or subtracting a plurality of predetermined values, 0.5, 1.0, 1.5, and 2.0, to or from the optimal value of indoor temperature of 23 °C.

[0023] For each setting value candidate calculated by the calculation module 123, the estimation module 124 estimates, using the sensor data acquired by the acquisition module 121, an indoor environment and energy consumption in a case where air conditioning is controlled using the setting value candidate calculated by the calculation module 123 as an indoor temperature setting value. For example, the estimation module 124 receives the setting value candidate calculated by the calculation module 123 and the sensor data acquired by the acquisition module 121 as inputs, and, for each setting value candidate

calculated by the calculation module 123, the estimation module 124 estimates, using an operation model, an indoor environment and energy consumption in the case where air conditioning is controlled using the setting value candidate calculated by the calculation module 123 as the indoor temperature setting value.

[0024] More specifically, the estimation module 124 receives the setting value candidate calculated by the calculation module 123 as well as the outdoor air condition, the indoor environment, and the air conditioner state acquired by the acquisition module 121 as inputs. For each setting value candidate calculated by the calculation module 123, the estimation module 124 estimates, using an air conditioner model and an indoor environment model, a return air temperature, a return air humidity, coil energy consumption, and fan energy consumption in the case where air conditioning is controlled using the setting value candidate calculated by the calculation module 123 as the indoor temperature setting value.

[0025] Here, a flow of estimation processing by the estimation module 124 is described with reference to FIG. 2. FIG. 2 illustrates an example of the flow of the estimation processing by the estimation module 124. The steps described below may be performed in a different order, and some processing may be omitted.

[0026] First, the estimation module 124 acquires a setting value candidate (step S101). For example, the estimation module 124 acquires the setting value candidate calculated by the calculation module 123. Subsequently, the estimation module 124 computes an indoor load according to supply air and return air information (step S102). For example, the estimation module 124 computes the indoor load using preset supply air and return air information.

[0027] Subsequently, the estimation module 124 performs an operation on an air conditioner model (step S103). For example, the estimation module 124 performs an operation regarding heat exchange or ventilation performed by a virtual air conditioner.

Subsequently, the estimation module 124 performs an operation on an indoor environment model (step S104). For example, the estimation module 124 performs an operation regarding a temperature, a humidity, a change in CO₂ or the like in a virtual indoor environment.

[0028] Subsequently, the estimation module 124 determines whether an update on an indoor temperature is equal to or less than a predetermined threshold (step S105). For example, if the estimation module 124 determines that the update on the indoor temperature is not equal to or less than 0.1 °C (“NO” in step S105), the estimation module 124 performs the processing in step S103 again. In the above example, 0.1 °C is used as the predetermined threshold. However, the estimation module 124 may use any value according to the purpose as the predetermined threshold at the time of determination in step S105.

[0029] On the other hand, for example, if the estimation module 124 determines that the update on the indoor temperature is equal to or less than 0.1 °C (“YES” in step S105), the estimation module 124 outputs the estimated indoor environment and energy consumption (step S106). For example, the estimation module 124 outputs the estimated indoor environment and energy consumption to other processing modules such as the determination module 125 or the selection module 126.

[0030] Referring back to FIG. 1, the description will be continued. The estimation module 124 performs an estimation using, as a target, the setting value candidate closest to the median among the setting value candidates calculated by the calculation module 123, and excludes, from estimation targets, setting value candidates whose value is larger or smaller than the setting value candidate on which the estimation has been performed. For example, the estimation module 124 performs an estimation using, as a target, the setting value candidate closest to the median among the setting value candidates calculated by the

calculation module 123, and excludes, from estimation targets, setting value candidates whose value is larger or smaller than the setting value candidate determined as a mismatch by the later-described determination module 125. More specifically, for example, the current indoor temperature is 32 °C. In the case where the setting value candidates calculated by the calculation module 123 are 20 °C, 21 °C, 22 °C, 23 °C, and 24 °C, the estimation module 124 performs estimation processing using, as a target, 22 °C that is closest to the median of the setting value candidates. If 22 °C is infeasible, the setting value candidates 20 °C and 21 °C whose values are smaller than 22 °C on which the estimation has been performed are excluded from estimation targets.

[0031] That is, the estimation module 124 performs an estimation by giving priority to the setting value candidate that is close to the median among the setting value candidates. If the setting value candidate is infeasible, setting value candidates considered to impose a greater load than the setting value candidate are excluded from estimation targets.

[0032] The determination module 125 determines whether the setting value candidate calculated by the calculation module 123 and the indoor environment estimated by the estimation module 124 match each other. For example, the determination module 125 determines whether the setting value candidate calculated by the calculation module 123 matches a return air temperature estimated value included in the indoor environment estimated by the estimation module 124. That is, by determining whether a certain setting value candidate matches the return air temperature estimated value being a result of estimation using the setting value candidate, the determination module 125 determines whether the setting value candidate is feasible.

[0033] Based on the indoor environment and the energy consumption estimated by the estimation module 124 as well as the allowable range of thermal sensation included in the thermal sensation-related information acquired by the acquisition module 121, the selection

module 126 selects the setting value candidate for indoor temperature. For example, if the thermal sensation corresponding to the indoor environment estimated by the estimation module 124 is within the allowable range of thermal sensation included in the thermal sensation-related information acquired by the acquisition module 121, the selection module 126 selects the setting value candidate having the smallest energy consumption from among the setting value candidates corresponding to the allowable range of thermal sensation. That is, if the estimated indoor environment satisfies a condition of Expression 3 below, the selection module 126 selects the setting value candidate having the smallest energy consumption. Here, $t^{\wedge}_{RA}$ stands for return air temperature estimated value. $h^{\wedge}_{RA}$ stands for return air humidity estimated value. F stands for the function that calculates the thermal sensation from a condition such as the indoor temperature.

[0034] $PMV - 0.5 < F_{pmv}(\hat{t}_{RA}, \hat{h}_{RA}) < PMV + 0.5 \quad \dots (3)$

[0035] More specifically, the selection module 126 calculates the thermal sensation corresponding to the indoor environment (24 °C to 25 °C) estimated by the estimation module 124 using the function that calculates the thermal sensation from a condition such as the indoor temperature. If the thermal sensation PMV corresponding to the indoor environment (return air temperature estimated value and return air humidity estimated value) is within the allowable range ($PMV = -0.5$ to $+0.5$) of thermal sensation included in the thermal sensation-related information acquired by the acquisition module 121, the selection module 126 selects the setting value candidate of 25 °C having the smallest energy consumption from among the setting value candidates corresponding to the allowable range of thermal sensation.

[0036] If the thermal sensation corresponding to the indoor environment estimated by the estimation module 124 is not within the allowable range of thermal sensation included in the thermal sensation-related information acquired by the acquisition module 121, the

selection module 126 selects the setting value candidate that is closest to the optimal value of indoor temperature computed by the computation module 122. That is, if all the estimated indoor environments fail to satisfy the condition of Expression 3 above, the selection module 126 selects the setting value candidate that is closest to the optimal value of indoor temperature computed by the computation module 122.

[0037] More specifically, if the thermal sensation corresponding to the indoor environment of 24 °C to 26 °C estimated by the estimation module 124 is 0.7 to 1.3, and is not within the allowable range ($PMV = -0.5$ to $+0.5$) of thermal sensation included in the thermal sensation-related information acquired by the acquisition module 121, the selection module 126 selects 24 °C that is closest to the optimal value of indoor temperature computed by the computation module 122.

[0038] [Processing by Information Processing Device]

Next, a flow of processing by the information processing device 100 will be described with reference to FIG. 3 to FIG. 6. First, the processing performed by the information processing device 100 is described with reference to FIG. 3. FIG. 3 is a diagram for describing the processing performed by the information processing device 100. In FIG. 3, the processing performed mainly by the estimation module 124 and the processing performed by other processing modules are shown separately. In FIG. 3, OA indicates outdoor air, EA indicates exhaust air, SA indicates supply air, and RA indicates return air. In FIG. 3, $t^{\wedge}_{RA}$ stands for return air temperature estimated value, $h^{\wedge}_{RA}$ stands for return air humidity estimated value, $E^{\wedge}_{coil}$ stands for coil energy consumption estimated value, and $E^{\wedge}_{fan}$ stands for fan energy consumption estimated value.

[0039] First, for example, as shown in FIG. 3, the acquisition module 121 acquires, from an external system such as a BAS, the sensor data such as an outdoor air condition of 30 °C, an indoor temperature of 26 °C, and an air conditioner state of “Active”. The acquisition

module 121 acquires the allowable range or optimal value of thermal sensation from another system. Subsequently, for example, the computation module 122 computes the optimal value of indoor temperature from the optimal value of thermal sensation acquired by the acquisition module 121. Subsequently, for example, the calculation module 123 calculates a setting value candidate of 25 °C for indoor temperature by processing such as adding or subtracting a predetermined value to or from the optimal value of indoor temperature. The information on the setting value candidate for indoor temperature calculated in this way is passed from the calculation module 123 to the estimation module 124 ((1) of FIG. 3).

[0040] Subsequently, for each setting value candidate for indoor temperature calculated by the calculation module 123, the estimation module 124 estimates, using the sensor data acquired by the acquisition module 121, an indoor environment and energy consumption in a case where air conditioning is controlled using the setting value candidate as an indoor temperature setting value. For example, the estimation module 124 estimates the return air temperature estimated value to be 25 °C, the return air humidity estimated value to be 50%, the coil energy consumption estimated value to be 12 kWh, and the fan energy consumption estimated value to be 6 kWh in the case where air conditioning is controlled using the setting value candidate of 25 °C as the indoor temperature setting value.

[0041] At this time, the estimation module 124 may perform the estimation processing on each setting value candidate one by one, or may perform the estimation processing in cooperation with the determination module 125 that determines the feasibility. For example, the estimation module 124 performs a simulation for the setting value candidate that is closest to the median of the setting value candidates, and the determination module 125 determines whether the setting value candidate and the return air temperature estimated value match each other. If the determination module 125 determines a mismatch, the estimation module 124 excludes, from estimation targets, setting value candidates whose

value is larger or smaller than the setting value candidate, from the viewpoint that the setting value candidate is infeasible. In this way, by excluding setting value candidates considered to be more difficult to realize than the setting value candidate estimated to be infeasible, the estimation processing can be performed in a binary search manner, the amount of calculation can be reduced, and processing load can be reduced.

[0042] According to the estimation processing described above, information on the indoor environment and the energy consumption estimated by the estimation module 124 is sent from the estimation module 124 to the selection module 126 ((2) of FIG. 3). Based on the indoor environment and the energy consumption estimated by the estimation module 124 as well as the allowable range of indoor temperature acquired by the acquisition module 121, the selection module 126 selects the setting value candidate for indoor temperature. That is, in the information processing device 100, a candidate for the indoor temperature setting value is calculated from the sensor data and thermal sensation-related information acquired. The setting value candidate is selected from the viewpoint of comfort or energy conservation using the indoor environment and the energy consumption estimated for each setting value candidate.

[0043] Subsequently, described with reference to FIG. 4 is an example of selecting a setting value candidate that is within the allowable range of thermal sensation and has the smallest energy consumption. FIG. 4 illustrates an example of the processing by the selection module 126. For example, as shown in the table of FIG. 4, in the case where the setting value candidates include 24 °C to 26 °C and the setting value candidates within the allowable range of thermal sensation is 24 °C to 25 °C, the selection module 126 selects the setting value candidate of 25 °C that is within the allowable range of thermal sensation and has the smallest energy consumption. An external system such as a BAS controls air conditioning so that the indoor temperature becomes the selected setting value. In this

way, in the information processing device 100, by selecting the setting value candidate that has an estimation result within the allowable range of thermal sensation and has the smallest energy consumption, it is possible to automatically operate an indoor temperature setting value considering energy consumption while ensuring user comfort.

[0044] Subsequently, described with reference to FIG. 5 is an example of selecting a setting value candidate that is closest to the optimal value of thermal sensation if all the setting value candidates are outside the allowable range of thermal sensation. FIG. 5 illustrates an example of the processing by the selection module 126. For example, as shown in the table of FIG. 5, in the case where the setting value candidates include 24 °C to 26 °C and all the setting value candidates are outside the allowable range of thermal sensation, the selection module 126 selects the setting value candidate 24 °C that is closest to the optimal value of thermal sensation. An external system such as a BAS controls air conditioning so that the indoor temperature becomes the selected setting value. In this way, in the information processing device 100, by selecting the setting value candidate that is closest to the optimal value of indoor temperature in the case where all the estimation results are outside the allowable range of thermal sensation, it is possible to automatically operate an indoor temperature setting value while ensuring user comfort.

[0045] Subsequently, an example of an infeasible setting value is described with reference to FIG. 6. FIG. 6 illustrates an example of an infeasible setting value. An infeasible setting value is a setting value when the setting value cannot be equal to the indoor temperature due to factors such as a discrepancy between an actual temperature and the setting value, outdoor air and indoor environmental conditions, and air conditioner limitations. For example, as shown in FIG. 6, in the case where the sensor data includes an outdoor air condition of 30 °C, an indoor temperature of 26 °C, and an air conditioner state of “Active”, the setting value candidate of 15 °C is an infeasible setting value. In the

example described in the present embodiment, as a result of the processing by the selection module 126, infeasible setting values are eliminated. That is, if the setting value candidate is within the allowable range of thermal sensation, the selection module 126 selects the setting value candidate having the smallest energy consumption; if all the setting value candidates are outside the allowable range of thermal sensation, the selection module 126 selects the setting value candidate closest to the optimal value of thermal sensation. Thereby, as a result, it is possible to eliminate infeasible setting values and select a suitable setting value candidate according to the situation.

[0046] [Flowchart]

Next, a flow of processing by the information processing device 100 is described with reference to FIG. 7. The steps described below may be performed in a different order, and some processing may be omitted.

[0047] First, the acquisition module 121 acquires sensor data and thermal sensation-related information (step S201). For example, the acquisition module 121 acquires, as the sensor data, information such as outdoor air condition, indoor environment, and air conditioner state, from an external system such as a BAS. For example, the acquisition module 121 acquires, as the thermal sensation-related information, information such as an allowable range of thermal sensation and an optimal value of thermal sensation, from an external system.

[0048] Subsequently, the computation module 122 computes an optimal value of indoor temperature from the optimal value of thermal sensation included in the thermal sensation-related information acquired by the acquisition module 121 (step S202). For example, the computation module 122 computes the optimal value of indoor temperature from the optimal value of thermal sensation using a function that calculates the thermal sensation from a condition such as the indoor temperature.

[0049] Subsequently, the calculation module 123 adds or subtracts a predetermined value to or from the optimal value of indoor temperature computed by the computation module 122, and calculates a setting value candidate for indoor temperature (step S203). For example, the calculation module 123 calculates, as the setting value candidate for indoor temperature, a value within a range from a value obtained by adding the predetermined value to the optimal value of indoor temperature computed by the computation module 122 to a value obtained by subtracting the predetermined value from the optimal value of indoor temperature. The predetermined value can be any value depending on the purpose.

[0050] Subsequently, for each setting value candidate calculated by the calculation module 123, the estimation module 124 estimates, using the sensor data acquired by the acquisition module 121, an indoor environment and energy consumption in a case where air conditioning is controlled using the setting value candidate calculated by the calculation module 123 as an indoor temperature setting value (step S204). For example, the estimation module 124 receives the setting value candidate calculated by the calculation module 123 and the sensor data acquired by the acquisition module 121 as inputs, and, for each setting value candidate calculated by the calculation module 123, the estimation module 124 estimates, using an operation model, an indoor environment and energy consumption in the case where air conditioning is controlled using the setting value candidate calculated by the calculation module 123 as the indoor temperature setting value.

[0051] Subsequently, the selection module 126 calculates thermal sensation from the estimated indoor environment (step S205). For example, the selection module 126 inputs a return air temperature estimated value and a return air humidity estimated value included in the estimated indoor environment to the function that calculates the thermal sensation from a condition such as the indoor temperature, and calculates the thermal sensation. Said

processing may be performed by the selection module 126 alone or in cooperation with any other processing module.

[0052] Subsequently, the selection module 126 determines whether the thermal sensation corresponding to the indoor environment estimated by the estimation module 124 is within an allowable range of thermal sensation included in the thermal sensation-related information acquired by the acquisition module 121 (step S206). Here, if it is determined by the selection module 126 that the thermal sensation corresponding to the indoor environment estimated by the estimation module 124 is within the allowable range of thermal sensation included in the thermal sensation-related information acquired by the acquisition module 121 (“YES” in step S206), the selection module 126 selects the setting value candidate having the smallest energy consumption from among the setting value candidates corresponding to the allowable range of thermal sensation (step S207).

[0053] On the other hand, if it is determined by the selection module 126 that the thermal sensation corresponding to the indoor environment estimated by the estimation module 124 is not within the allowable range of thermal sensation included in the thermal sensation-related information acquired by the acquisition module 121 (“NO” in step S206), the selection module 126 selects the setting value candidate that is closest to the optimal value of indoor temperature computed by the computation module 122 (step S208).

[0054] [Effects]

The information processing device 100 according to an embodiment includes: the acquisition module 121, acquiring sensor data and thermal sensation-related information; the calculation module 123, calculating a setting value candidate for indoor temperature based on the thermal sensation-related information acquired by the acquisition module 121; the estimation module 124, for each setting value candidate calculated by the calculation module 123, estimating, using the sensor data acquired by the acquisition module 121, an

indoor environment and energy consumption in a case where air conditioning is controlled using the setting value candidate calculated by the calculation module 123 as an indoor temperature setting value; and the selection module 126, selecting the setting value candidate for indoor temperature based on the indoor environment and the energy consumption estimated by the estimation module 124 as well as an allowable range of thermal sensation included in the thermal sensation-related information acquired by the acquisition module 121.

[0055] Accordingly, in the information processing device 100, by selecting the setting value candidate based on the indoor environment and energy consumption estimated for each setting value candidate calculated from the acquired thermal sensation-related information, it is possible to automatically operate an indoor temperature setting value considering energy consumption while ensuring user comfort.

[0056] The calculation module 123 of the information processing device 100 according to an embodiment calculates, as the setting value candidate for indoor temperature, a temperature corresponding to the allowable range of thermal sensation included in the thermal sensation-related information acquired by the acquisition module 121.

[0057] Accordingly, in the information processing device 100, by selecting the setting value candidate based on the indoor environment and energy consumption estimated for each setting value candidate corresponding to the allowable range of thermal sensation calculated from the acquired thermal sensation-related information, it is possible to automatically operate an indoor temperature setting value considering energy consumption while ensuring user comfort.

[0058] The information processing device 100 according to an embodiment further includes: the computation module 122, computing an optimal value of indoor temperature from the optimal value of thermal sensation included in the thermal sensation-related

information acquired by the acquisition module 121. The calculation module 123 adds or subtracts a predetermined value to or from the optimal value of indoor temperature computed by the computation module 122, and calculates the setting value candidate for indoor temperature.

[0059] Accordingly, in the information processing device 100, by selecting the setting value candidate based on the indoor environment and energy consumption estimated for each setting value candidate calculated by adding or subtracting the predetermined value to or from the optimal value of thermal sensation computed from the acquired thermal sensation-related information, it is possible to automatically operate an indoor temperature setting value considering energy consumption while ensuring user comfort.

[0060] The estimation module 124 of the information processing device 100 according to an embodiment performs an estimation using, as a target, the setting value candidate closest to the median among the setting value candidates calculated by the calculation module 123, and excludes, from estimation targets, setting value candidates whose value is larger or smaller than the setting value candidate on which the estimation has been performed. Accordingly, in the information processing device 100, estimation processing is performed from, with priority given to, a candidate that is close to the median of the setting value candidates. By excluding candidates having a value larger or smaller from estimation targets, the estimation processing can be performed in a binary search manner, the amount of calculation can be reduced, and processing load can be reduced.

[0061] If the thermal sensation corresponding to the indoor environment estimated by the estimation module 124 is within the allowable range of thermal sensation included in the thermal sensation-related information acquired by the acquisition module 121, the selection module 126 of the information processing device 100 according to an embodiment selects the setting value candidate having the smallest energy consumption from among the setting

value candidates corresponding to the allowable range of thermal sensation. Accordingly, in the information processing device 100, by selecting the setting value candidate that has an estimation result within the allowable range of thermal sensation and has the smallest energy consumption, it is possible to automatically operate an indoor temperature setting value considering energy consumption while ensuring user comfort.

[0062] If the thermal sensation corresponding to the indoor environment estimated by the estimation module 124 is not within the allowable range of thermal sensation included in the thermal sensation-related information acquired by the acquisition module 121, the selection module 126 of the information processing device 100 according to an embodiment selects the setting value candidate that is closest to the optimal value of indoor temperature computed by the computation module 122. Accordingly, in the information processing device 100, by selecting the setting value candidate that is closest to the optimal value of indoor temperature in the case where all the estimation results are outside the allowable range of thermal sensation, it is possible to automatically operate an indoor temperature setting value while ensuring user comfort.

[0063] The information processing device 100 according to an embodiment further includes: the determination module 125, determining whether the setting value candidate calculated by the calculation module 123 and the indoor environment estimated by the estimation module 124 match each other. The estimation module 124 excludes, from estimation targets, setting value candidates whose value is larger or smaller than the setting value candidate determined as a mismatch by the determination module 125. Accordingly, in the information processing device 100, estimation processing is performed from, with priority given to, a candidate that is close to the median of the setting value candidates. If the setting value is infeasible, by excluding candidates having a value larger or smaller from

estimation targets, the estimation processing can be performed in a binary search manner, the amount of calculation can be reduced, and processing load can be reduced.

[0064] [Program]

It is also possible to create a program in which the processing executed by the information processing device 100 described in the above embodiment is described in a language executable by a computer. In this case, by the computer executing the program, the same effects as those of the above embodiment can be achieved. Furthermore, such a program may be recorded on a computer-readable recording medium, and the program recorded on this recording medium may be read into a computer for execution, thereby realizing the same processing as in the above embodiment.

[0065] FIG. 8 illustrates an example of a computer that executes an information processing program. As shown in FIG. 8, a computer 1000 includes, for example, a memory 1010, a CPU 1020, a hard disk drive interface 1030, a disk drive interface 1040, a serial port interface 1050, a video adapter 1060, and a network interface 1070. These parts are connected by a bus 1080.

[0066] The memory 1010 includes a read only memory (ROM) 1011 and a RAM 1012. The ROM 1011 stores a boot program such as a basic input/output system (BIOS). The hard disk drive interface 1030 is connected to a hard disk drive 1090. The disk drive interface 1040 is connected to a disk drive 1100. A removable storage medium such as a magnetic disk or an optical disk is inserted into the disk drive 1100. A mouse 1110 and a keyboard 1120, for example, are connected to the serial port interface 1050. A display 1130, for example, is connected to the video adapter 1060.

[0067] Here, as shown in FIG. 8, the hard disk drive 1090 stores, for example, an OS 1091, an application program 1092, a program module 1093, and program data 1094. Each

table described in the above embodiment is stored in, for example, the hard disk drive 1090 or the memory 1010.

[0068] The information processing program is stored in the hard disk drive 1090, for example, as a program module in which a command to be executed by the computer 1000 is described. Specifically, the program module 1093 in which each processing executed by the computer 1000 described in the above embodiment is described is stored in the hard disk drive 1090.

[0069] Data used for information processing by the information processing program is stored as program data in, for example, the hard disk drive 1090. The CPU 1020 reads out the program module 1093 and the program data 1094 stored in the hard disk drive 1090 to the RAM 1012 as necessary, and executes each step described above.

[0070] The program module 1093 or the program data 1094 related to the information processing program is not limited to being stored in the hard disk drive 1090 and may, for example, be stored in a removable storage medium and be read out by the CPU 1020 via the disk drive 1100 or the like. The program module 1093 or the program data 1094 related to the information processing program may be stored in another computer connected via a network such as a local area network (LAN) or a wide area network (WAN), and be read out by the CPU 1020 via the network interface 1070.

[0071] [Others]

Although various embodiments have been described in detail in the present specification with reference to the drawings, these embodiments are examples and are not intended to limit the present invention to these embodiments. The features described in the present specification can be implemented in a variety of ways, including various modifications or improvements based on the knowledge of those skilled in the art.

[0072] The term “module” or the term ending with the suffix “-er” or “-or” mentioned above can be read as a unit, a means, a circuit, or the like. For example, communication module, control module and storage module can be read as communication unit, control unit, and storage unit, respectively.

Description of Reference Numerals

[0073] 100: information processing device

110: communication module

120: control module

121: acquisition module

122: computation module

123: calculation module

124: estimation module

125: determination module

126: selection module

130: storage module

CLAIMS

Claim 1:

An information processing device, comprising:

an acquisition module configured to acquire sensor data and thermal sensation-related information;

a calculation module configured to calculate a setting value candidate for indoor temperature based on the thermal sensation-related information acquired by the acquisition module;

an estimation module, for each of the setting value candidate to be calculated by the calculation module, configured to estimate, using the sensor data acquired by the acquisition module, an indoor environment and energy consumption in a case where air conditioning is to be controlled using the setting value candidate calculated by the calculation module as an indoor temperature setting value; and

a selection module configured to select the setting value candidate for indoor temperature based on the indoor environment and the energy consumption estimated by the estimation module as well as an allowable range of thermal sensation comprised in the thermal sensation-related information acquired by the acquisition module,

wherein if the thermal sensation corresponding to the indoor environment estimated by the estimation module is not within the allowable range of thermal sensation comprised in the thermal sensation-related information acquired by the acquisition module, the selection module is configured to select the setting value candidate that is closest to an optimal value of indoor temperature, and

the estimation module is further configured to perform a simulation for the setting value candidate and exclude the setting value candidate being infeasible based on the simulation.

Claim 2:

The information processing device according to claim 1, wherein

the calculation module is further configured to calculate, as the setting value candidate for indoor temperature, a temperature corresponding to the allowable range of thermal sensation comprised in the thermal sensation-related information acquired by the acquisition module.

Claim 3:

The information processing device according to claim 1, further comprising:

a computation module is further configured to compute the optimal value of indoor temperature from an optimal value of thermal sensation comprised in the thermal sensation-related information acquired by the acquisition module, wherein

the calculation module is further configured to add or subtract a predetermined value to or from the optimal value of indoor temperature computed by the computation module, and calculate the setting value candidate for indoor temperature.

Claim 4:

The information processing device according to claim 1, wherein

the estimation module is configured to perform an estimation using, as a target, the setting value candidate closest to a median among the setting value candidates calculated by the calculation module, and exclude, from estimation targets, setting value candidates whose value is larger or smaller than the setting value candidate on which the estimation has been performed.

Claim 5:

The information processing device according to claim 1, wherein,

if the thermal sensation corresponding to the indoor environment estimated by the estimation module is within the allowable range of thermal sensation comprised in the thermal sensation-related information acquired by the acquisition module, the selection module is configured to select the setting value candidate having the smallest energy consumption from among the setting value candidates corresponding to the allowable range of thermal sensation.

Claim 6:

The information processing device according to claim 4, further comprising:

a determination module is configured to determine whether the setting value candidate calculated by the calculation module and the indoor environment estimated by the estimation module match each other, wherein

the estimation module is configured to exclude, from estimation targets, setting value candidates whose value is larger or smaller than the setting value candidate determined as a mismatch by the determination module.

Claim 7:

An information processing method being a method performed by an information processing device, comprising:

an acquisition process, in which sensor data and thermal sensation-related information are acquired;

a calculation process, in which a setting value candidate for indoor temperature is calculated based on the thermal sensation-related information acquired by the acquisition process;

an estimation process in which, for each of the setting value candidate calculated by the calculation process, an indoor environment and energy consumption in a case where air conditioning is controlled using the setting value candidate calculated by the calculation process as an indoor temperature setting value are estimated using the sensor data acquired by the acquisition process; and

a selection process, in which the setting value candidate for indoor temperature is selected based on the indoor environment and the energy consumption estimated by the estimation process as well as an allowable range of thermal sensation comprised in the thermal sensation-related information acquired by the acquisition process,

wherein if the thermal sensation corresponding to the indoor environment estimated by the estimation process is not within the allowable range of thermal sensation comprised in the thermal sensation-related information acquired by the acquisition process, the selection process selects the setting value candidate that is closest to an optimal value of indoor temperature, and

the estimation process performs a simulation for the setting value candidate and excludes the setting value candidate being infeasible based on the simulation.

Claim 8:

An information processing program, causing a computer to execute:

an acquisition step of acquiring sensor data and thermal sensation-related information;

a calculation step of calculating a setting value candidate for indoor temperature based on the thermal sensation-related information acquired by the acquisition step;

an estimation step of estimating, for each of the setting value candidate calculated by the calculation step, using the sensor data acquired by the acquisition step, an indoor environment and energy consumption in a case where air conditioning is controlled using the setting value candidate calculated by the calculation step as an indoor temperature setting value; and

a selection step of selecting the setting value candidate for indoor temperature based on the indoor environment and the energy consumption estimated by the estimation step as well as an allowable range of thermal sensation comprised in the thermal sensation-related information acquired by the acquisition step,

wherein if the thermal sensation corresponding to the indoor environment estimated by the estimation step is not within the allowable range of thermal sensation comprised in the thermal sensation-related information acquired by the acquisition step, the selection step selects the setting value candidate that is closest to an optimal value of indoor temperature, and

the estimation step performs a simulation for the setting value candidate and excludes the setting value candidate being infeasible based on the simulation.