

RADIANT ENVIRONMENT EVALUATION SYSTEM AND RADIANT
ENVIRONMENT EVALUATION METHOD

Background

5 [0001] The present invention relates to a radiant environment evaluation system and a radiant environment evaluation method for evaluating an in-room radiant environment of, mainly, a resident area in a building.

10 [0002] A facility manager controls air conditioning for an air conditioning environment in a building with less sacrificing comfortability. For the in-room comfort evaluation, it is known that four elements of environmental physical quantity affect thermal comfortability of in-room people. The four elements of environmental physical quantity include room temperature, humidity, wind speed, and radiation (mean radiant temperature). PMV (Predicted Mean Vote) is a comfort index of ISO (International Organization for Standardization). PMV (Predicted Mean Vote) is
15 calculated in consideration of those four elements.

20 [0003] Typically, there are mainly known two methods of obtaining a mean radiant temperature of a resident area in a building. One is a method of measuring a globe temperature (method 1). The other is a method of using
25 surface temperatures representative of planes surrounding a human body (method 2) (for example, see Japanese Patent Application Laid-open No. 2011-127782).

30 [0004] Note that the mean radiant temperature MRT (mean radiative temperature) means "the temperature of a black globe having the radiant heat quantity equivalent to a mean value of radiant heat effects that a human body

or an object receives from the surround in all the directions". In a resident area in a building, in many cases, a primary radiant source that affects the in-room environment is a window surface or a wall surface, whose temperature is increased or decreased affected by sunlight or outside air.

[0005] [Problem of method 1]

The globe temperature is an equivalent temperature under the effect of radiation of an unheating globe and convection.

[0006] The method 1 uses a hollow-body copper globe whose surface is coated with matte black paint. The temperature of the inside of the hollow-body copper globe is measured by using a mercury-in-glass thermometer, a thermocouple, a thermistor, or the like. This temperature is treated as a globe temperature. The thermometer that measures the globe temperature is called globe thermometer.

[0007] Fig. 16 schematically shows a typical globe thermometer.

[0008] Fig. 16 shows the globe (hollow-body copper globe) 201 whose surface is coated with matte black paint, the mercury-in-glass thermometer 202 that measures the temperature around the center of the globe 201 as the globe temperature T_g , and the support cap 203 that supports the mercury-in-glass thermometer 202.

[0009] The mean radiant temperature T_r is calculated on the basis of the globe temperature T_g measured by the aforementioned globe thermometer, the air temperature T_a surrounding the globe, which is independently measured, and the measured wind speed v , by using the following

Formula (1).

[0010]
$$Tr = Tg + 2.37\sqrt{v}(Tg - Ta) \dots (1)$$

Where Tr: mean radiant temperature [$^{\circ}\text{C}$], Ta: air temperature [$^{\circ}\text{C}$], Tg: globe temperature [$^{\circ}\text{C}$], and v: wind speed [m/s].

[0011] In the formula of calculating the mean radiant temperature Tr, if the room has relatively stable airflow, an approximate representative value may be used as the wind speed v. Further, a value measured by a temperature sensor in the room for air conditioning control or the like may be used as the air temperature Ta. According to this method, it is possible to measure a mean radiant temperature that well corresponds to a sense of a human body.

[0012] However, according to this method, it is necessary to provide a place in which a globe thermometer is arranged to measure the temperature at a height and a position representative of a resident area, i.e., in a work space of in-room people. It hinders business work of in-room people. In addition, the globe thermometer may be displaced by in-room people, and may thereby be damaged or lost. Such problems may occur in management of the globe thermometer.

[0013] Further, in a resident area in a building, the layout is changed frequently. For example, desks of in-room people are displaced, and devices, furniture, and the like are introduced and removed. So it is difficult to fix the position, at which the globe thermometer is placed, at the time of construction.

[0014] In the aforementioned circumstances, it is not practical to use the method 1 for a long time for the

purpose of everyday control/environment management used in a building. This is because it is necessary for the method 1 to arrange the globe thermometer in a resident area. The method 1 is temporarily employed for the purpose of demonstration tests or researches. In other words, the method 1 is not practical. Because of such a demerit, the running cost of the method 1 has to be increased substantially.

[0015] [Problem of method 2]

The method 2 uses surface temperatures representative of planes surrounding a human body. The method 2 uses the surface temperatures of the surfaces (windows, walls, a ceiling, etc.), which are primary radiant sources for a resident area.

[0016] Examples of a method of measuring a surface temperature include a method of measuring a temperature of a target surface by using a contact thermometer, and a contactless method of measuring a temperature of a target surface by using a radiant thermometer, an infrared measure device such as thermography, or the like.

According to both the methods, typically, a sensor or a device that measures a surface temperature of a primary radiant source is placed outside a work space of in-room people. For example, a sensor or a device may be placed on a window, a wall, a floor, a ceiling, a pole, or the like. The aforementioned arrangement and management problems of the method 1 may be improved.

[0017] However, according to the method 2, when calculating the mean radiant temperature T_r of the surface temperatures T_N of the measured surfaces N (N : integer indicating surface's ID), it is necessary to

calculate the view factor F_{P-N} , which is determined on the basis of the positional relation between each surface N and the evaluation position P, and the like.

[0018] A method of calculating a view factor is disclosed in general documents. In addition, as a calculation tool, "ASHRAE

Comfort Tool (ASHRAE: American Society of Heating, Refrigerating, and Air-Conditioning Engineers)" is disclosed (<https://www.ashrae.org/resources--publications/bookstore/thermal-comfort-tool>).

[0019] The view factor is a rate of each surface temperature that affects the mean radiant temperature T_r . The sum of the view factors from all the surfaces that affect the mean radiant temperature T_r is 1. For example, if a room has a typical rectangular parallelepiped shape (see Fig. 17), the mean radiant temperature T_r is obtained by using the following Formula (2) on the basis of the surface temperatures T_N representative of six planes (a ceiling, a floor, and four walls) ($N=1$ to 6).

[0020] [Math 1]

$$T_r = \sum_{N=1}^6 T_N \cdot F_{P-N} \quad \cdots (2)$$

Where T_r : mean radiant temperature [$^{\circ}\text{C}$], T_N : surface temperature [$^{\circ}\text{C}$] of the surface N, and F_{P-N} : view factor from the surface N to evaluation position P in evaluation shape.

[0021] The view factor F_{P-N} used in Formula (2) depends on the geometric positional relation between the shape (depth D, width W, height H) of a residence space being an evaluation target and the evaluation shape (for

example, shape of a surface, shape of a person, etc.) at the evaluation position. In other words, as shown in Fig. 18, for example, the view factor F_{P1-A} from the surface A to the human body at the evaluation position P1 is different from the view factor F_{P3-A} from the surface A to the human body at the evaluation position P3 ($F_{P1-A} \neq F_{P3-A}$). Note that, typically, in the radiant environment evaluation of a resident area, when determining a view factor, the shape of a person in consideration of the posture such as standing and sitting is selected as the evaluation shape. In other words, the evaluation shape is preselected and predetermined by a solution provider for environment evaluation/control, etc. or a facility manager as necessary. The view factor is determined on the basis of the relation between the shape of a residence space being the evaluation target and the evaluation position.

[0022] Therefore, if the radiant environment evaluation is executed for a plurality of evaluation positions, it is necessary to calculate the view factor F_{P-N} from each surface to each evaluation position P with reference to the drawings or the like of a building. An engineering cost is increased if the method 2 is applied to a real building, which is a problem.

[0023] In view of the aforementioned circumstances, it is desirable to provide a radiant environment evaluation system and a radiant environment evaluation method capable of substantially decreasing a running cost of evaluating a mean radiant temperature, and also capable of decreasing an engineering cost.

Summary

[0024] According to an embodiment of the present invention, there is provided a radiant environment evaluation system, including: a view factor storage module (1) that stores a view factor from each boundary plane surrounding an evaluation unit space (U) to an evaluation position (P) in the evaluation unit space (U), the evaluation unit space (U) being a space having a predetermined size; a temperature information obtaining module (6) that obtains, as temperature information, a surface temperature (T_s) of a physical boundary plane of an evaluation target space (M) of a radiant environment, or an air temperature (T_a) of the evaluation target space (M); an obtained temperature information managing module (4) that manages and stores the temperature information obtained by the temperature information obtaining module (6) for each arrangement space (MU), the temperature information being boundary plane temperature information (T_e) of a surface temperature (T_s) of a physical boundary plane for a boundary plane in contact with the physical boundary plane of the evaluation target space (M), the temperature information being boundary plane temperature information (T_e) of an air temperature (T_a) of an arrangement space (MU) for a boundary plane not in contact with the physical boundary plane of the evaluation target space (M), the boundary plane surrounding the arrangement space (MU), the arrangement space (MU) being the evaluation unit space (U) in the evaluation target space (M); and a mean radiant temperature calculating module (5) that calculates a mean radiant temperature (T_r) of the evaluation position (P)

in the arrangement space (MU) for each arrangement space (MU) on a basis of the boundary plane temperature information (T_e) of each arrangement space (MU) stored in the obtained temperature information managing module (4) and the view factor from each boundary plane of the evaluation unit space (U) stored in the view factor storage module (1).

[0025] According to an embodiment of the present invention, the view factor storage module stores a view factor from each boundary plane surrounding an evaluation unit space to an evaluation position in the evaluation unit space. The temperature information obtaining module obtains, as temperature information, a surface temperature of a physical boundary plane of an evaluation target space of a radiant environment, or an air temperature of the evaluation target space (one of or both of the surface temperature of the physical boundary plane of the evaluation target space and the air temperature in the evaluation target space). The obtained temperature information managing module manages and stores the temperature information obtained by the temperature information obtaining module for each arrangement space, the temperature information being boundary plane temperature information of a surface temperature of a physical boundary plane for a boundary plane in contact with the physical boundary plane of the evaluation target space, the temperature information being boundary plane temperature information of an air temperature of an arrangement space for a boundary plane not in contact with the physical boundary plane of the evaluation target space, the boundary plane surrounding

the evaluation unit space (arrangement space) in the evaluation target space. The mean radiant temperature calculating module calculates a mean radiant temperature of the evaluation position in the arrangement space for each arrangement space on a basis of the boundary plane temperature information of each arrangement space stored in the obtained temperature information managing module and the view factor from each boundary plane of the evaluation unit space stored in the view factor storage module.

[0026] According to an embodiment of the present invention, if some of the physical boundary planes of the evaluation target space are in contact with physical boundary planes of the arrangement space, surface temperatures of the physical boundary planes of the arrangement space may not necessarily be measured for all the physical boundary planes of all the arrangement spaces. The measured surface temperature of a physical boundary plane in the evaluation target space may be used instead of a surface temperature of a physical boundary plane, which is in contact with the aforementioned physical boundary plane, of another arrangement space, which is not measured. Further, the air temperature may not necessarily be measured for all the arrangement spaces. The measured air temperature of the evaluation target space may be used instead of an air temperature of another arrangement space, which is not measured, in consideration of the positional relation of the air temperature measuring position and the arrangement space in the evaluation target space, a thermal disturbance, and the like.

[0027] Note that, in the aforementioned description, for example, the configurational elements in the drawings corresponding to the configurational elements of the present invention are denoted by reference symbols with
5 brackets.

[0028] As described above, according to an embodiment of the present invention, it is possible to calculate a mean radiant temperature at an evaluation position in each evaluation unit space (arrangement space) arranged
10 in an evaluation target space, while a view factor to an evaluation position in an evaluation unit space, which is stored in a view factor storage module, is reused. It is possible to substantially decrease a running cost for evaluating a mean radiant temperature, and also to
15 decrease an engineering cost.

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

Brief Description of Drawings

[0029] Fig. 1 schematically shows arrangement of evaluation unit spaces in a radiant environment evaluation target space;

25 Fig. 2A shows an example of air conditioning zones arranged in a building;

Fig. 2B shows an example of air conditioning zones arranged in a building;

30 Fig. 3 schematically shows an evaluation target space, an evaluation unit space, and arrangement spaces;

Fig. 4 is a plan view showing the evaluation target

space and the arrangement spaces of Fig. 3;

Fig. 5 shows a fundamental configuration of a radiant environment evaluation system according to an embodiment of the present invention;

5 Fig. 6 illustrates a method of determining boundary plane IDs of an evaluation unit space;

Fig. 7 illustrates evaluation unit spaces and view factor information, in which each evaluation unit space includes a plurality of evaluation positions;

10 Fig. 8 illustrates temperature information sent from a surface temperature obtaining module and an air temperature obtaining module to an obtained temperature information managing module;

15 Fig. 9 illustrates boundary plane status information (boundary plane status S (MU_j , Bi)) stored in the obtained temperature information managing module;

Fig. 10 shows an example of an operational flow of generating calculated temperature information by the obtained temperature information managing module;

20 Fig. 11 shows an example of calculated temperature information (calculated temperature $Te(MU_j, Bi)$) generated by the obtained temperature information managing module;

25 Fig. 12 schematically shows calculated temperature information generated every ten minutes;

Fig. 13 shows an example of an operational flow of calculating a mean radiant temperature by the mean radiant temperature calculating module;

30 Fig. 14 illustrates evaluation points $Q1$ and $Q1'$, whose positional relations are bilaterally symmetrical;

Fig. 15 shows the evaluation unit spaces R and R' ,

whose relations are bilaterally symmetrical, arranged in an evaluation target space;

Fig. 16 schematically shows a globe thermometer;

Fig. 17 schematically shows a room having a typical rectangular parallelepiped shape, and effects of radiation from surrounding surfaces to an in-room person; and

Fig. 18 illustrates different view factors from the surface A to human bodies at the evaluation positions P1 and P3.

Detailed Description of Embodiments

[0030] [Principle of invention]

Firstly, before describing an embodiment of the present invention, a principle of the present invention will be described. The present invention employs the aforementioned method 2. In the method 2, surface temperatures representative of surfaces surrounding a human body is used. According to the method 2, an engineering cost is increased primarily by calculating the view factor F_{P-N} . So, by making the calculating step simple, the engineering cost may be decreased easily and greatly.

[0031] According to findings of the present inventors, an evaluation unit space, whose radiant environment is to be evaluated, is preset and reused, and view factors can thus be calculated in a simple way. If an evaluation unit space is set, then it is possible to precalculate view factors from all the surrounding planes to the evaluation position in the evaluation unit space.

Further, according to findings of the present inventors, the evaluation unit space is arranged in places in a

building, which are to be evaluated, and the evaluation unit space is used. Then, according to findings of the present inventors, it is not necessary to calculate new view factors corresponding to the places to be evaluated.

5 [0032] Fig. 1 schematically shows arrangement of evaluation unit spaces in a radiant environment evaluation target space (a space zone to be evaluated in a building). Fig. 1 schematically shows a radiant environment evaluation target space M and an evaluation unit space U.

10 [0033] If the evaluation unit space U and the evaluation position P in the evaluation unit space U are set, it is possible to precalculate view factors F_{P-N} (F_{P-N1} , F_{P-N2} , F_{P-N3} , F_{P-N4} , F_{P-N5} , F_{P-N6}) from the six surrounding planes (plane N1 to plane N6) to the evaluation position P.

15 [0034] The evaluation unit space U is arranged in the evaluation target space M, and the precalculated view factors F_{P-N} (F_{P-N1} , F_{P-N2} , F_{P-N3} , F_{P-N4} , F_{P-N5} , F_{P-N6}) are used. Then it is not necessary to calculate new view factors for each evaluation position P corresponding to a positional relation between the evaluation target space M and the evaluation position P.

20 [0035] For example, the arrangement space MU (MU1) is the evaluation unit space U arranged in the evaluation target space M. In the arrangement space MU (MU1), the view factor F_{P-N1} from the plane N1 to the evaluation position P of the evaluation unit space U is used as the view factor F_{P1-A1} from the plane A1 to the evaluation position P1 ($F_{P1-A1}=F_{P-N1}$).

25 [0036] Further, the arrangement space MU (MU2) is the

evaluation unit space U arranged in the evaluation target space M. In the arrangement space MU (MU2), the the view factor F_{P-N1} from the plane N1 to the evaluation position P of the evaluation unit space U is used as the the view factor F_{P2-A2} from the plane A2 to the evaluation position P2 ($F_{P2-A2}=F_{P-N1}$).

[0037] Further, the arrangement space MU (MU3) is the evaluation unit space U arranged in the evaluation target space M. In the arrangement space MU (MU3), the the view factor F_{P-N1} from the plane N1 to the evaluation position P of the evaluation unit space U is used as the the view factor F_{P3-A3} from the plane A3 to the evaluation position P3 ($F_{P3-A3}=F_{P-N1}$).

[0038] Note that, in the present description, the arrangement space MU means the evaluation unit space U arranged in the evaluation target space M, the arrangement position of the evaluation unit space U being determined.

[0039] Further, in design of a building, it is rare that management units of lighting, air conditioning, and the like have different sizes in one building. For example, typically, as illustrated in Fig. 2A and Fig. 2B, the air conditioning zone (i.e., air conditioning management unit) is divided into two types of zones. The two types of zones include the perimeter zone(s) Z1 arranged in the outer area(s) of a building, and the interior zone Z2 inside the perimeter zone(s) Z1. In this case, typically, the sizes of the perimeter zones Z1 are the same, and the sizes of the interior zones Z2 are the same.

[0040] In a high-rise building, in many cases, the

zone sizes of different floors are the same except for floors of different use (for example, commercial facility floors in an office building). As described above, an evaluation unit space is set on the basis of an in-room environment (such as lighting and air conditioning) management unit. Then, a management unit, which a facility manager is usually in charge of, coincides with an evaluation unit space of a radiant environment. Therefore it is possible to avoid troublesome management of a building space, and a running cost may be further reduced substantially.

[0041] Further, the larger the distance from a radiant source, the more the attenuation of the view factor. So, in principle and in practical, most of heat effects from radiant sources, i.e., window surfaces/exterior wall surfaces, to a resident area can be ignored. In addition, in a typical building such as an office in which people reside, furniture, partitions, and the like are arranged in resident areas. Typically, the surface temperature values of furniture, partitions, carpets, and the like far from a radiant source are close to the air temperature of the resident area around them. This is because, if there is a temperature difference, then heat is transferred and the temperature difference is thereby canceled.

[0042] From the viewpoint of the aforementioned circumstances, the present inventors have found that, if a plane surrounding an evaluation unit space (arrangement space) arranged in an evaluation target space is not a physical window or wall, the temperature of the plane is approximated to the representative air temperature of the

arrangement space, and that the mean radiant temperature evaluation can be sufficiently practical. Further, by employing this scheme, the step of calculating the view factor F_{P-N} can be made simple. As a result, a running cost can be reduced substantially, and an engineering cost can also be reduced.

[0043] [Embodiment]

Hereinafter, an embodiment of the present invention will be described in detail with reference to the drawings.

[Outline of embodiment]

Firstly, an outline of the present embodiment will be described. In the present embodiment, an evaluation unit space is determined on the basis of space information (floor size, building exterior information, etc.) of a radiant environment evaluation target space. The size of the evaluation unit space and an evaluation point in the evaluation unit space are determined. The determined evaluation unit space is arranged in the evaluation target space. A mean radiant temperature of an evaluation point is obtained for each arranged evaluation unit space (arrangement space).

[0044] In the present embodiment, an evaluation target space (in the present embodiment, a floor in a building) is divided into spaces (rectangular parallelepiped) having the same size. An evaluation point in the rectangular parallelepiped is determined. The rectangular parallelepiped including the evaluation point is treated as an evaluation unit space. The size of a unit of a rectangular parallelepiped, i.e., the evaluation unit space, and the position of the evaluation

point in the evaluation unit space are fixed. As a result, view factors from the six planes surrounding the evaluation unit space to the evaluation point can also be fixed.

5 [0045] The evaluation unit space determined as described above is arranged in the evaluation target space (arrangement space). The view factors from the six planes surrounding each arrangement space to the evaluation point coincide with the view factors from the
10 six planes surrounding the evaluation unit space to the evaluation point. Therefore, a mean radiant temperature is calculated by using the fixed view factors from the six planes of the evaluation unit space and by using surface temperatures of the six planes of each
15 arrangement space, and a radiant environment of each arrangement space can thus be evaluated. The combination of the view factors of the evaluation unit space can be used repeatedly for arrangement spaces. Therefore the engineering cost for calculating view factors can be
20 reduced.

[0046] In this embodiment, if an arbitrary plane (boundary plane) surrounding an arrangement space is not an actual physical surface (wall, window, etc.), a representative air temperature of the arrangement space
25 is treated as the temperature of the plane during calculation.

[0047] [Details of embodiment]

Fig. 3 schematically shows an evaluation target space and an evaluation unit space of the present
30 embodiment. The evaluation unit space U and the evaluation position P therein are predetermined by a

solution provider for environment evaluation/control, etc.
or a facility manager in consideration of the size of the
evaluation target space M, which is the evaluation target
in an in-building space, the statuses of surrounding

5 boundary planes such as walls and windows of the
evaluation target space M, the positions to be evaluated,
the number of the positions to be evaluated, and the like.

[0048] A plurality of types of evaluation unit spaces

U may be determined (for example, a plurality of types
10 having different sizes, etc.). However, for simplicity,

one kind of evaluation unit space U will be described in
the present embodiment. Further, a plurality of

evaluation positions P may be determined in the

evaluation unit space U. However, for simplicity, one

15 evaluation position P in the evaluation unit space U will
be described in the present embodiment.

[0049] In the present embodiment, the evaluation

target space M is between a ceiling and a floor. The

evaluation target space M has east, west, and south

20 physical boundary planes such as walls and a window. The

evaluation target space M has a north boundary plane,

which is not a physical boundary and communicates with

another space on the same floor (see Fig. 4).

[0050] Further, in the present embodiment, as shown in

25 Fig. 3, the six evaluation unit spaces U are arranged in

the evaluation target space M, and each evaluation unit

space U includes one evaluation position P. Each

evaluation unit space U arranged in the evaluation target

space M is treated as the arrangement space MU. The

30 environment of each arrangement space MU is evaluated.

The aforementioned example will be described.

[0051] Further, in the present embodiment, contact thermometers, infrared sensors, and the like measure surface temperatures representative of the physical boundary planes such as windows, walls, the ceiling, and the floor of the evaluation target space M.

[0052] Further, in the present embodiment, the air temperature representative of each arrangement space MU is also measured. In the present embodiment, the arrangement space MU may coincide with an air conditioning zone (zone as a unit of air conditioning control such as a zone of an air conditioner and a VAV zone), or may be an integral multiple of the air conditioning zone. In such a case, a value detected by a temperature sensor for air conditioning control may be used as a representative air temperature, which is more preferable.

[0053] In the present embodiment, for simplicity, a space in one floor of a building is treated as the evaluation target space M. As a matter of course, however, the present embodiment is also applicable to evaluation target spaces M on a plurality of floors of a high-rise building or evaluation target spaces M of a plurality of buildings. In this case, if an evaluation unit space U having a similar shape can be reused for a plurality of floors or for a plurality of buildings, an engineering cost can be further decreased. Further, as described above, in design of a building, in many cases, in-room environment management units such as lighting and air conditioning have similar sizes. If the evaluation unit space U is set on the basis of the in-room environment management unit, an engineering cost may be further

decreased.

[0054] Fig. 5 shows a fundamental configuration of a radiant environment evaluation system according to an embodiment of the present invention. The radiant environment evaluation system 100 is realized by hardware including a processor and a storage device, and a program. When the hardware executes the program, the hardware operates to realize various functions. The radiant environment evaluation system 100 includes the evaluation unit information storage module 1, the surface temperature obtaining module 2, the air temperature obtaining module 3, the obtained temperature information managing module 4, and the mean radiant temperature calculating module 5.

[0055] In the radiant environment evaluation system 100, the surface temperature obtaining module 2 and the air temperature obtaining module 3 operate as the temperature information obtaining module 6. The temperature information obtaining module 6 and the obtained temperature information managing module 4 operate as the temperature obtaining system 7. Further, the information providing module 8 is connected to the radiant environment evaluation system 100. The information providing module 8 provides results calculated by the mean radiant temperature calculating module. Alternatively, the radiant environment evaluation system 100 may include the information providing module 8.

[0056] Note that, in the present embodiment, the surface temperature obtaining module 2 and the air temperature obtaining module 3 send obtained temperature

information to the obtained temperature information managing module 4 at predetermined intervals (every ten minutes). The obtained temperature information managing module 4 receives the temperature information, and generates calculated temperature information. Such an example will be described. The timing at which the obtained temperature information managing module 4 receives data from the surface temperature obtaining module 2 and the air temperature obtaining module 3 is not limited to the aforementioned example. The timing at which the obtained temperature information managing module 4 generates the calculated temperature information to be used by the mean radiant temperature calculating module 5 is not limited to the aforementioned example.

[0057] For example, a user (a person who evaluates the environment, a facility manager, etc.) specifies date/time and a place to be evaluated, a mean radiant temperature corresponding to the date/time and the place is calculated, and the mean radiant temperature is provided to the user. In this case, it is sufficient that calculated temperature information necessary to calculate a mean radiant temperature be obtained by the time at which the mean radiant temperature calculating module 5 calculates the mean radiant temperature. They are arbitrary design matters. They do not affect the present invention, which has an effect of making the step of calculating the view factor F_{P-N} simple.

[0058] <Description of configurational elements of the radiant environment evaluation system 100>

[Evaluation unit information storage module 1]

The evaluation unit information storage module 1

stores, as evaluation unit space information (view factor information), information of a view factor from each boundary plane surrounding the evaluation unit space U to the evaluation position P. The view factor is
5 predetermined and set by a solution provider for environment evaluation/control, etc. or a facility manager on the basis of the size of the evaluation unit space U and the evaluation position P.

[0059] [Surface temperature obtaining module 2]

10 The surface temperature obtaining module 2 obtains the surface temperature Ts of each physical boundary plane of the evaluation target space M. The surface temperature obtaining module 2 sends the surface temperature Ts, the obtaining date/time, and the
15 obtaining target information to the obtained temperature information managing module 4. A sensor, a device, or the like (contact thermometer, infrared sensor, etc.) physically measures the surface temperature Ts of each physical boundary plane. Alternatively, the surface
20 temperature Ts may be obtained by executing simulation of heat transfer, fluid, or the like in the evaluation target space M.

[0060] A solution provider for in-room environment evaluation/control, etc. or a facility manager may
25 construct a sensors/devices installation environment and a simulation environment necessary to obtain surface temperatures with general work mainly without special difficulty. Note that, for example, the obtaining date/time is the measuring date/time if the surface
30 temperature Ts is measured and obtained. The obtaining date/time is the estimated date/time of the surface

temperature if the surface temperature T_s is obtained by simulation. Further, the obtained temperature information managing module 4 determines, on the basis of the obtaining target information sent from the surface temperature obtaining module 2, which physical boundary plane of the evaluation target space M has the obtained surface temperature T_s . The obtaining target information sent from the surface temperature obtaining module 2 may be any information with which the obtained temperature information managing module 4 can determine the physical boundary plane. For example, if the surface temperature T_s is measured and obtained, the obtaining target information sent from the surface temperature obtaining module 2 may be the position (obtaining position or measuring position) of a measure sensor, the ID of the measure sensor, or the like.

[0061] [Air temperature obtaining module 3]

The air temperature obtaining module 3 obtains the air temperature T_a of the evaluation target space M. The air temperature obtaining module 3 sends the air temperature T_a , the obtaining date/time, and the obtaining target information to the obtained temperature information managing module 4. A sensor, a device, or the like, which measures the room temperature, physically measures the air temperature T_a . Alternatively, the air temperature T_a may be obtained by executing simulation of heat transfer, fluid, or the like in the evaluation target space M.

[0062] A solution provider for in-room environment evaluation/control, etc. or a facility manager may construct a sensors/devices installation environment and

a simulation environment necessary to obtain air temperature with general work mainly without special difficulty. Note that the obtaining date/time is the measuring date/time if the air temperature T_a is measured and obtained. The obtaining date/time is the estimated date/time of the air temperature if the air temperature T_a is obtained by simulation. Further, the obtained temperature information managing module 4 determines, on the basis of the obtaining target information sent from the air temperature obtaining module 3, which arrangement space MU of the evaluation target space M corresponds to the obtained air temperature T_a . The obtaining target information sent from the air temperature obtaining module 3 may be any information with which the obtained temperature information managing module 4 can determine the physical boundary plane. For example, if the air temperature T_a is measured and obtained, the obtaining target information sent from the air temperature obtaining module 3 may be the position (obtaining position or measuring position) of a measure sensor, the ID of the measure sensor, or the like.

[0063] [Obtained temperature information managing module 4]

The obtained temperature information managing module 4 obtains information sent from the surface temperature obtaining module 2 and the air temperature obtaining module 3. The obtained temperature information managing module 4 makes the surface temperature T_s and the air temperature T_a in association with the arrangement space MU arranged in the evaluation target space M and the boundary planes of the arrangement space MU, and in

association with the obtaining date/time. The obtained temperature information managing module 4 thus generates integrated calculated temperature information. Further, the obtained temperature information managing module 4
5 manages and stores the generated calculated temperature information.

[0064] [Average radiant temperature calculating module 5]

The mean radiant temperature calculating module 5
10 calculates the mean radiant temperature T_r of the evaluation position P of each arrangement space MU arranged in the evaluation target space M. The mean radiant temperature calculating module 5 calculates the mean radiant temperature T_r by using the view factor
15 information of the evaluation unit space U stored in the evaluation unit information storage module 1 and the calculated temperature information sent from the obtained temperature information managing module 4.

[0065] [Information providing module 8]

20 The information providing module 8 provides the mean radiant temperature T_r of each arrangement space MU calculated by the mean radiant temperature calculating module 5 in association with the place of the arrangement space MU and the place of the evaluation position P to a
25 user (a person who evaluates the environment, a facility manager, etc.). In this case, the information providing module 8 may provide a list or a graph illustrating the mean radiant temperatures T_r of the arrangement spaces MU. Alternatively, as a matter of course, the information
30 providing module 8 may display the mean radiant temperatures T_r on the arrangement spaces MU or the

evaluation positions P on a layout drawing showing the evaluation target space M. As a result, a user may more easily understand the relation between the mean radiant temperatures T_r and the places. Further, the mean
5 radiant temperatures T_r in time series of an arbitrary arrangement space MU may be shown in a table or a graph on the basis of the obtaining date/time.

[0066] Further, a comfort index such as PMV (predicted mean vote) and SET (standard new effective temperature)
10 may be calculated by using the mean radiant temperature T_r calculated by the mean radiant temperature calculating module 5. The comfort index may be provided to a user in association with the place of the arrangement space MU or the place of the evaluation position P. The comfort
15 index may be provided in time series for each arrangement space MU. In those cases, the radiant environment evaluation system 100 additionally includes, as necessary, a comfort index calculating module that calculates a comfort index.

20 [0067] <Primary information stored by configurational elements of radiant environment evaluation system 100, and primary operations>

[View factor information of evaluation unit information storage module 1]

25 The evaluation unit information storage module 1 prestores, as view factor information, boundary plane identifier information (ID, name, etc.), which identifies the evaluation unit space U and its boundary planes, and view factors from the boundary planes to the evaluation
30 position P, in association with each other.

[0068] As shown in Fig. 3, the size of the evaluation

target space M of the present embodiment is 30 m (D)*16 m (W)*2.7 m (H). The size of the evaluation unit space U is 10 m (d)*8 m (w)*2.7 m (h). The coordinates (X', Y', Z') of the evaluation position P in the evaluation unit space U are (5 m, 4 m, 0.6 m). Note that the evaluation shape of the present embodiment is the shape of a person sitting on the floor surface. So the Z coordinate is 0.6 m in height, which is typically used for a thermal environment of a person sitting on the floor surface.

[0069] Further, in the present embodiment, boundary plane identifier information is B_i (i is an integer from 1 to α . α : the number of the boundary planes of the evaluation unit space U (in the present embodiment, $\alpha=6$)). Fig. 6 is a plan view showing the evaluation unit space U. As shown in Fig. 6, the south boundary plane B_1 is treated as a reference plane. There are the west, north, and east boundary planes B_2 , B_3 , and B_4 in the clockwise direction. The ceiling surface is the boundary plane B_5 . The floor surface is the boundary plane B_6 .

[0070] The view factor F_{P-B_i} from the boundary plane B_i to the evaluation position P can be obtained on the basis of the size of the evaluation unit space U and the coordinates of the evaluation position P by using, for example, "ASHRAE Thermal Comfort tool" in conformity with "ASHRAE standard 55-2010" or the like. In the present embodiment, the following numerical values are prestored by a solution provider for environment evaluation/control, etc. or a facility manager.

$$\{F_{P-B_1}, F_{P-B_2}, F_{P-B_3}, F_{P-B_4}, F_{P-B_5}, F_{P-B_6}\} = \{0.055, 0.085, 0.055, 0.085, 0.282, 0.430\} \dots (3)$$

[0071] In the present embodiment, if there are a

plurality of evaluation unit spaces U and a plurality of evaluation positions P, as shown in Fig. 7, the view factor F_{P-Bi} from each boundary plane Bi calculated for each ID of the evaluation unit space U (evaluation unit space ID) and each ID of the evaluation position P (evaluation position ID) is prestored. The view factor F_{P-Bi} is used as the view factor information.

[0072] For example, as shown in Fig. 2A and Fig. 2B, the perimeter zone Z1 and the interior zone Z2, which are management units of air conditioning control, are set as evaluation unit space IDs U1 and U2. One or more evaluation positions are determined for each of the evaluation unit spaces U1 and U2. The view factor is calculated for the evaluation position corresponding to each of the evaluation unit spaces U1 and U2. The view factor is prestored, and is used as the view factor information.

[0073] [Operation of surface temperature obtaining module 2 and air temperature obtaining module 3]

The surface temperature obtaining module 2 obtains a surface temperature representative of each boundary plane of each physical boundary plane of the evaluation target space M such as a window, a wall, a ceiling, and a floor. The surface temperature obtaining module 2 adds obtaining target information, which identifies each boundary plane, to the surface temperature. The surface temperature obtaining module 2 sends the surface temperature, the obtaining target information, and the obtaining date/time to the obtained temperature information managing module 4 as the temperature information (surface temperature information).

[0074] According to the present embodiment, the surface temperature obtaining module 2 measures a surface temperature representative of each boundary plane of each physical boundary plane of the evaluation target space M such as a window, a wall, a ceiling, and a floor by using a contact thermometer or an infrared sensor.

[0075] In this case, for example, in Fig. 8, the surface temperature $T_s(M, W1)$ is measured for the south window surface W1 by using a contact thermometer or an infrared sensor. In Fig. 8, the surface temperatures $T_s(M, W2)$ and $T_s(M, W4)$ are measured for the west and east wall surfaces W2 and W4 by using contact thermometers or infrared sensors. In Fig. 8, the surface temperatures $T_s(M, W5)$ and $T_s(M, W6)$ are measured for the ceiling surface W5 and the floor surface W6 by using contact thermometers or infrared sensors. In Fig. 8, the north plane is not a physical boundary plane, and its surface temperature is thus not measured. The aforementioned measurement results, the obtaining date/time (measuring date/time), and the obtaining target information are sent to the obtained temperature information managing module 4 as the temperature information (surface temperature information). In the present embodiment, the obtaining target information means information that identifies the wall surface W_k (in this example, $k=1, 2, 4, 5, 6$) of the evaluation target space M to be measured.

[0076] Note that, in this example, the surface temperature of one point of each physical boundary plane such as a window, a wall, a ceiling, and a floor of the evaluation target space M is measured. Alternatively,

the temperatures of all the physical boundary planes out of the boundary planes of all the arrangement spaces MU_j arranged in the evaluation target space M (j is an integer from 1 to β . β : the number of the arrangement spaces MU (in the present embodiment, $\beta=6$)) may be measured. Their temperature information may be sent to the obtained temperature information managing module 4.

[0077] The air temperature obtaining module 3 measures the air temperature representative of the arrangement space MU for each arrangement space MU . In this case, for example, as shown in Fig. 8, the air temperature obtaining module 3 measures the air temperatures $T_a(MU1)$ to $T_a(MU6)$ of the arrangement spaces $MU1$ to $MU6$. The air temperature obtaining module 3 adds the obtaining target information, which identifies the arrangement space MU to be measured, to the air temperature T_a . The air temperature obtaining module 3 sends the air temperature T_a , the obtaining target information, and the obtaining date/time to the obtained temperature information managing module 4 as the temperature information (air temperature information).

[0078] [Operation of obtained temperature information managing module 4]

The obtained temperature information managing module 4 stores the boundary plane status $S(MU_j, B_i)$ indicating whether or not each boundary plane B_i of the arrangement space MU_j is a physical boundary plane, for each arrangement space MU_j arranged in the evaluation target space M (see Fig. 9). In the example of Fig. 9, "1" indicates a physical boundary plane, and "0" indicates a non-physical boundary plane.

[0079] In the present embodiment, a solution provider for environment evaluation/control, etc. or a facility manager predetermines information of the boundary plane status by using information about the sizes, the positions, and the like of the evaluation target space M and the arrangement space MU. In another embodiment, the surface temperature obtaining module 2 measures temperatures of the physical boundary planes out of the boundary planes of all the arrangement spaces MU_j arranged in the evaluation target space M. The surface temperature obtaining module 2 sends the temperature information to the obtained temperature information managing module 4. In this case, "1" (physical boundary plane) may indicate a boundary plane, whose surface temperature is to be sent by the surface temperature obtaining module 2, and "0" (non-physical boundary plane) may indicate a boundary plane other than that. The information of the boundary plane status may be automatically generated.

[0080] The obtained temperature information managing module 4 integrates the temperature information (obtaining target information, obtaining date/time, and temperature data) received from the surface temperature obtaining module 2 and the air temperature obtaining module 3. The obtained temperature information managing module 4 generates the calculated temperatures $T_e(MU_j, B_i)$ (calculated temperature information) of all the arrangement spaces MU and boundary planes, which are used to calculate the mean radiant temperature by the mean radiant temperature calculating module 5.

[0081] The obtained temperature information managing

module 4 determines the calculated temperature $T_e(\text{MUj}, \text{Bi})$ of the arbitrary arrangement space MUj and the arbitrary boundary plane Bi as follows. If the boundary plane is a physical boundary plane ($S(\text{MUj}, \text{Bi})=1$), the obtained temperature information managing module 4 determines, as the calculated temperature $T_e(\text{MUj}, \text{Bi})$, the surface temperature $T_s(\text{MUj}, \text{Bi})$ obtained on the basis of the surface temperature $T_s(\text{M}, \text{Wk})$ sent from the surface temperature obtaining module 2. If the boundary plane is a non-physical boundary plane ($S(\text{MUj}, \text{Bi})=0$), the obtained temperature information managing module 4 determines, as the calculated temperature $T_e(\text{MUj}, \text{Bi})$, the air temperature $T_a(\text{MUj})$ sent from the air temperature obtaining module 3.

[0082] [Math 2]

Where $S(\text{MUj}, \text{Bi})=1$, $T_e(\text{MUj}, \text{Bi})=T_s(\text{MUj}, \text{Bi})$
Where $S(\text{MUj}, \text{Bi})=0$, $T_e(\text{MUj}, \text{Bi})=T_a(\text{MUj}) \dots (4)$
Where i is an integer from 1 to α ($\alpha=6$), and j is an integer from 1 to β ($\beta=6$).

[0083] Fig. 10 shows an example of an operational flow of generating calculated temperature information by the obtained temperature information managing module 4. The obtained temperature information managing module 4 receives temperature information from the temperature information obtaining module 6. Then the obtained temperature information managing module 4 initializes $i=1$ and $j=1$ at the start of the operational flow (Step S101). The obtained temperature information managing module 4 confirms whether or not the boundary plane status $S(\text{MUj}, \text{Bi})$ is "1" (Step S102). In the present embodiment, if the boundary plane status $S(\text{MUj}, \text{Bi})$ is "1" (Step S102,

YES), the obtained temperature information managing module 4 uses the calculated temperature $T_e(\text{MUj}, \text{Bi}) = T_s(\text{MUj}, \text{Bi})$ (Step S103). If the boundary plane status $S(\text{MUj}, \text{Bi})$ is "0" (Step S102, NO), the obtained temperature information managing module 4 uses the calculated temperature $T_e(\text{MUj}, \text{Bi}) = T_a(\text{MUj})$ (Step S104). Further, the obtained temperature information managing module 4 increments i ($i=i+1$) (Step S105), determines Step S106, and repeats the process from Step S102 to Step S106.

[0084] During the process, if $i > \alpha$ is satisfied (Step S106, YES), i.e., if all the boundary planes Bi of one arrangement space MUj are processed, the obtained temperature information managing module 4 increments j ($j=j+1$) (Step S107), determines Step S108, and repeats the process from Step S102 to Step S108. During the process, if $j > \beta$ is satisfied (Step S108, YES), i.e., if all the arrangement spaces MUj are processed, a series of process is finished. Fig. 11 shows the calculated temperatures $T_e(\text{MUj}, \text{Bi})$ obtained in this way. In Fig. 11, the calculated temperatures of the physical boundary planes are hatched, which are different from the calculated temperatures of the non-physical boundary planes.

[0085] Note that, in this example, in Step S103, the surface temperature $T_s(\text{M}, \text{W1})$ from the surface temperature obtaining module 2 is treated as the south surface temperatures $T_s(\text{MU1}, \text{B1})$ and $T_s(\text{MU4}, \text{B1})$ of the arrangement spaces MU1 and MU4 . The surface temperature $T_s(\text{M}, \text{W2})$ from the surface temperature obtaining module 2 is treated as the west surface temperatures $T_s(\text{MU4}, \text{B2})$,

Ts(MU5, B2), and Ts(MU6, B2) of the arrangement spaces MU 4, MU5, and MU6. The surface temperature Ts(M, W4) from the surface temperature obtaining module 2 is treated as the east surface temperatures Ts(MU1, B4), Ts(MU2, B4), and Ts(MU3, B4) of the arrangement spaces MU1, MU2, and MU3. Further, the surface temperature Ts(M, W5) from the surface temperature obtaining module 2 is treated as the ceiling surface temperatures Ts(MU1, B5) to Ts(MU6, B5) of the arrangement spaces MU1 to MU6. The surface temperature Ts(M, W6) from the surface temperature obtaining module 2 is treated as the floor surface temperatures Ts(MU1, B6) to Ts(MU6, B6) of the arrangement spaces MU1 to MU6.

[0086] In this example, the surface temperature of one point of each physical boundary plane such as a window, a wall, a ceiling, and a floor of the evaluation target space M is measured. Alternatively, the temperatures of the physical boundary planes such as a window, a wall, a ceiling, and a floor out of the boundary planes of all the arrangement spaces MUj arranged in the evaluation target space M may be measured by using contact thermometers, infrared sensors, or the like. Their temperature information may be sent to the obtained temperature information managing module 4. Further, if a plurality of surface temperatures of one physical boundary plane of one arrangement space MU are measured, for example, a mean value or a representative value of each boundary plane may be employed. The surface temperature may thus be determined.

[0087] As described above, in the present embodiment, at predetermined intervals (every ten minutes), the

surface temperature obtaining module 2 and the air temperature obtaining module 3 send temperature information (surface temperature information and air temperature information) to the obtained temperature information managing module 4. The obtained temperature information managing module 4 integrates the temperature information from the surface temperature obtaining module 2 and the air temperature obtaining module 3, and thereby generate calculated temperature information. Fig. 12 schematically shows calculated temperature information generated every ten minutes. Note that, in Fig. 12, the calculated temperatures of the physical boundary planes are hatched, which are different from the calculated temperatures of the non-physical boundary planes.

[0088] [Operation of mean radiant temperature calculating module 5]

Fig. 13 shows an example of an operational flow of calculating a mean radiant temperature by the mean radiant temperature calculating module 5. The mean radiant temperature calculating module 5 initializes $i=1$, $j=1$, and $Tr(MU_j)=0$ at the start of the operational flow (Step S201). In the present embodiment, $Tr(MU_j)$ indicates a mean radiant temperature of the arrangement space MU_j arranged in the evaluation target space M .

[0089] Further, the mean radiant temperature calculating module 5 obtains the view factor F_{P-B_i} from the boundary plane B_i to the evaluation position P of the evaluation target space U by using the view factor information (in the present embodiment, Formula (3)) stored in the evaluation unit information storage module 1 (Step S202). The mean radiant temperature calculating

module 5 obtains the calculated temperature $Te(MUj, Bi)$ of the boundary plane Bi of the arrangement space MUj on the basis of the calculated temperature information from the obtained temperature information managing module 4 (Step S203). In the present embodiment, Step S202 may be executed before Step S203, or Step S203 may be executed before Step S202.

[0090] Next, the mean radiant temperature calculating module 5 calculates the following Formula (5). The mean radiant temperature calculating module 5 thus adds, to $Tr(MUj)$, the radiant effect from the boundary plane Bi to the evaluation position P of the arrangement space MUj (Step S204).

$$Tr(MUj) = Tr(MUj) + F_{P-Bi} * Te(MUj, Bi) \dots (5)$$

[0091] Further, the mean radiant temperature calculating module 5 increments i ($i=i+1$) (Step S205). The mean radiant temperature calculating module 5 repeats the process from Step S202 to Step S206 until $i > \alpha$ is satisfied in Step S206 (α : the number of the boundary planes of the evaluation target space U , which is the same as the number of the boundary planes of the arrangement space MUj). As a result, the radiant effects from all the boundary planes Bi of one arrangement space MUj are summed up. The mean radiant temperature $Tr(MUj)$, which is described with reference to Formula (2), of the arrangement space MUj is obtained.

[0092] In repeating of the process, if $i > \alpha$ is satisfied (Step S206, YES), the mean radiant temperature calculating module 5 calculates $i=1$, $j=j+1$, and $Tr(MUj)=0$ (Step S207). The mean radiant temperature calculating module 5 repeats Step S202 to Step S208 until $j > \beta$ is

satisfied (β : the number of the arrangement spaces MU of the evaluation target space M).

[0093] In repeating the process, if $j > \beta$ is satisfied (Step S208, YES), a series of process is finished. In this way, by incrementing j one by one, the mean radiant temperature $Tr(MU_j)$ of each of all the arrangement spaces MU_j of the evaluation target space M is obtained.

[0094] Note that, in the aforementioned embodiment, the evaluation target space is filled with the arrangement spaces. However, it is not necessary to fill the evaluation target space with the arrangement spaces. Alternatively, the arrangement spaces may not be in contact with each other, and an arbitrary number of arrangement spaces may be arranged at positions to be evaluated. Alternatively, arrangement spaces may partly overlap each other. Note that the arrangement spaces should not be outside the evaluation target space. Further, the surface temperature or the air temperature to be obtained and used in calculating the mean radiant temperature for all the boundary planes of the arrangement space should be determined and preset.

[0095] Further, in the aforementioned embodiment, the air temperature of each arrangement space is measured. However, if the air temperature of each arrangement space is not measured, a measured air temperature in an evaluation target space may be alternatively used instead of an air temperature of each arrangement space, which is not measured. This is similar to a temperature of a physical boundary plane of an arrangement space described in the embodiment.

[0096] Further, in the aforementioned embodiment, the

positional relation from the boundary planes to the evaluation position of the arrangement space are the same.

Alternatively, the relative positional relation between the boundary planes and the evaluation position of one

arrangement space may be the same as the relative positional relation between the boundary planes and the

evaluation position of another arrangement space. A relatively corresponding view factor may be applied to

such an arrangement space as long as the relative

positional relations between the boundary planes and the evaluation position coincide with each other. In other

words, a relatively corresponding view factor is applied to a different arrangement space out of a plurality of

arrangement spaces, a relative positional relation

between an evaluation position and each boundary plane of one arrangement space coinciding with a relative

positional relation between an evaluation position and each boundary plane of the different arrangement space.

As a result, it is possible to calculate the mean radiant temperature of the evaluation position of the different

arrangement space.

[0097] For example, the following Formula (6)

indicates the combination of the view factors of the evaluation point Q1 of Fig. 14. Then the following

Formula (7) indicates the combination of the view factors of the evaluation point Q1', whose positional relation is

bilaterally symmetrical.

[0098] [View factors of evaluation point Q1]

$\{F_{Q1-B1}, F_{Q1-B2}, F_{Q1-B3}, F_{Q1-B4}, F_{Q1-B5}, F_{Q1-B6}\} \dots (6)$

[0099] [View factors of evaluation point Q1']

$\{F_{Q1'-B1}, F_{Q1'-B2}, F_{Q1'-B3}, F_{Q1'-B4}, F_{Q1'-B5}, F_{Q1'-B6}\} = \{F_{Q1-B3},$

$F_{Q1-B2}, F_{Q1-B1}, F_{Q1-B4}, F_{Q1-B5}, F_{Q1-B6}\} \dots (7)$

[0100] As apparent from the comparison between Formula (6) and Formula (7), the relatively corresponding view factors are applicable to the evaluation points Q1 and Q1', whose positional relations are bilaterally symmetrical. The view factors are thus reusable.

[0101] Further, for example, Fig. 15 shows the evaluation unit spaces R and R', whose relations are bilaterally symmetrical. Then the view factor information of the evaluation unit space R is reused depending on their correspondence relations. As a result, it is not necessary to calculate the view factor information of the evaluation unit space R'.

[0102] As described above, a relatively corresponding view factor may be applied as long as the relative positional relations between the boundary planes and the evaluation point coincide with each other, in which arrangement spaces are bilaterally symmetrical or rotationally symmetrical. In other words, those arrangement spaces have a relation in which the view factor information of a common evaluation unit space is applicable. The present invention does not intend to exclude a case in which the relative positional relations coincide with each other as described above.

[0103] [Extension of embodiment]

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

What is claimed is:

1. A radiant environment evaluation system, comprising:

a view factor storage module that stores a view factor from each boundary plane surrounding an evaluation unit space to an evaluation position in the evaluation unit space, the evaluation unit space being a space having a predetermined size;

a temperature information obtaining module that obtains, as temperature information, a surface temperature of a physical boundary plane of an evaluation target space of a radiant environment, or an air temperature of the evaluation target space;

an obtained temperature information managing module that manages and stores the temperature information obtained by the temperature information obtaining module for each arrangement space,

the temperature information being boundary plane temperature information of a surface temperature of a physical boundary plane for a boundary plane in contact with the physical boundary plane of the evaluation target space,

the temperature information being boundary plane temperature information of an air temperature of an arrangement space for a boundary plane not in contact with the physical boundary plane of the evaluation target space,

the boundary plane surrounding the arrangement space, the arrangement space being the evaluation unit space in the evaluation target space; and

a mean radiant temperature calculating module that calculates a mean radiant temperature of the evaluation

position in the arrangement space for each arrangement space on a basis of the boundary plane temperature information of each arrangement space stored in the obtained temperature information managing module and the view factor from each boundary plane of the evaluation unit space stored in the view factor storage module.

2. The radiant environment evaluation system according to claim 1, wherein

the evaluation unit space has a size equal to a size of a unit of air conditioning control in the evaluation target space, or equal to an integral multiple of the size of the unit of air conditioning control.

3. The radiant environment evaluation system according to claim 1 or 2, wherein

the mean radiant temperature calculating module applies a relatively corresponding view factor to a different evaluation unit space out of a plurality of evaluation unit spaces, a relative positional relation between an evaluation position and each boundary plane of one evaluation unit space coinciding with a relative positional relation between an evaluation position and each boundary plane of the different evaluation unit space, and

calculates a mean radiant temperature of an evaluation position in an arrangement space, the arrangement space including the different evaluation unit space arranged in the evaluation target space.

4. A radiant environment evaluation method, comprising:

a view factor storing step including storing, in a view factor storage module, a view factor from each boundary plane surrounding an evaluation unit space to an

evaluation position in the evaluation unit space, the evaluation unit space being a space having a predetermined size;

5 a temperature information obtaining step including obtaining, as temperature information, a surface temperature of a physical boundary plane of an evaluation target space of a radiant environment, or an air temperature of the evaluation target space;

10 an obtained temperature information managing step including managing and storing, by an obtained temperature information managing module, the temperature information obtained in the temperature information obtaining step for each arrangement space,

15 the temperature information being boundary plane temperature information of a surface temperature of a physical boundary plane for a boundary plane in contact with the physical boundary plane of the evaluation target space,

20 the temperature information being boundary plane temperature information of an air temperature of an arrangement space for a boundary plane not in contact with the physical boundary plane of the evaluation target space,

25 the boundary plane surrounding the arrangement space, the arrangement space being the evaluation unit space in the evaluation target space; and

30 a mean radiant temperature calculating step including calculating a mean radiant temperature of the evaluation position in the arrangement space for each arrangement space on a basis of the boundary plane temperature information of each arrangement space stored

in the obtained temperature information managing module and the view factor from each boundary plane of the evaluation unit space stored in the view factor storage module.

5 5. The radiant environment evaluation method according to claim 4, wherein

 the evaluation unit space has a size equal to a size of a unit of air conditioning control in the evaluation target space, or equal to an integral multiple of the
10 size of the unit of air conditioning control.

6. The radiant environment evaluation method according to claim 4 or 5, wherein

 the mean radiant temperature calculating step includes

15 applying a relatively corresponding view factor to a different evaluation unit space out of a plurality of evaluation unit spaces, a relative positional relation between an evaluation position and each boundary plane of one evaluation unit space coinciding with a relative
20 positional relation between an evaluation position and each boundary plane of the different evaluation unit space, and

 calculating a mean radiant temperature of an evaluation position in an arrangement space, the
25 arrangement space including the different evaluation unit space arranged in the evaluation target space.