

SPECIFICATION

NAME OF INVENTION: BEHAVIOR DETECTION SYSTEM, INTERFACE DEVICE,
AND ROBOT

TECHNICAL FIELD

[0001]

The present invention relates to a behavior detection system, an interface device, and a robot.

BACKGROUND ART

[0002]

In order for a computer to detect a location of a human or an object, electronic map information is often used which is information simulating a real space. A technique of creating such map information by a self-propelled robot has been widely used. Patent Document 1 discloses that when a robot creates map information moving along a traveling path of the robot itself, the robot acquires a feature of a surrounding area. The feature of the surrounding area measured by the robot includes, for example, a distance between a floor on which the robot is located and an obstacle located above the floor, a material of the floor, a dust pollution level thereof. Patent Document 2 discloses that a map creation device: superposes and synthesizes a surrounding geometric shape obtained at a position and another surrounding geometric shape obtained at another position; and thereby creates synthesized map information. In synthesizing, the map creation device of Patent Document 2 uses a distance between the two positions, an amount of a parallel translation of a wall which is detected as a plane containing the two positions, or the like.

RELATED ART DOCUMENTS

PATENT DOCUMENTS

[0003]

Patent Document 1: Japanese Laid-Open Patent Application, Publication No. 2007-323652

Patent Document 2: Japanese Laid-Open Patent Application, Publication No. 2010-054315

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004]

When a mobile device such as a robot is provided, especially indoors, in many cases, a sensor for detecting a human or an object is also provided. In some of those cases, on an assumption that the sensor and the robot coexist with each other, the sensor and the robot are required to share such operations as creation of map information, detection of a human or an object, and an appropriate approach to a human or an object. Such a need is particularly increased, when, for example, an elderly person present in a room is watched over or is assisted. Patent Document 1 fails to disclose a sensor other than a robot and also fails to disclose a watch over on or an approach to a person or the like. Patent Document 2 fails to disclose a sensor other than a robot and also fails to disclose a watch over on or an approach to a person or the like.

In light of the described above, the present invention has been made in an attempt that a robot makes an appropriate approach to a person or the like in an environment in which a sensor is installed.

MEANS FOR SOLVING THE PROBLEMS

[0005]

A behavior detection system includes: a plurality of sensor devices, each of which includes a first sensor configured to detect information and a first communication part configured to transmit information, and is installed in an indoor space; a robot that includes a second sensor configured to detect information, a second communication part configured to receive and transmit information, and a

traveling part by which the robot itself can travel in the indoor space; a server that includes a third communication part configured to receive and transmit information and that is configured to detect behavior of a mobile entity in the indoor space, based on detection information which is information detected by the first sensor of each of a plurality of the sensor devices and another detection information which is information detected by the second sensor of the robot; and an interface device configured to allow a user to enter, on a screen, data on a position at which each of a plurality of the sensor devices is installed in the indoor space.

Other means for solving the problem will be described in embodiments for carrying out the present invention.

ADVANTAGEOUS EFFECTS OF THE INVENTION

[0006]

In an aspect of the present invention, a robot can make an appropriate approach to a human or the like in an environment in which a sensor is installed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

[FIG. 1] A schematic block diagram illustrating a configuration of a behavior detection system according to a first embodiment of the present invention.

[FIG. 2] A diagram illustrating a living space in which the behavior detection system is established according to the first embodiment.

[FIG. 3] A diagram illustrating an example of sensor installation information (SI).

[FIG. 4] A diagram illustrating an example of event information (EI).

[FIG. 5] A diagram illustrating the living space in a sensor installation information (SI) mode.

[FIG. 6] A graph illustrating sensor information (GI).

[FIG. 7] A flowchart illustrating a processing of a sensor information creation mode.

[FIG. 8] A flowchart illustrating a processing of a sensor installation information

mode according to the first embodiment.

[FIG. 9] A diagram illustrating a living space in an event information mode.

[FIG. 10] A graph illustrating sensor information (GI) in the event information mode.

[FIG. 11] A flowchart illustrating a processing of the event information mode.

[FIG. 12] A graph only illustrating extracted event information (EI).

[FIG. 13] A flowchart illustrating a processing of the event information mode in which the mobile robot is not started.

[FIG. 14] A flowchart illustrating a processing of the event information mode in which the mobile robot is in an operating state.

[FIG. 15] A diagram illustrating a living space when anomaly has been detected.

[FIG. 16] A graph illustrating no detection response extracted of the event information.

[FIG. 17] A flowchart illustrating a processing of an anomaly detection mode.

[FIG. 18] A schematic block diagram illustrating a configuration of a behavior detection system according to a second embodiment of the present invention.

[FIG. 19] A schematic block diagram illustrating a configuration of a behavior detection system according to a third embodiment of the present invention.

[FIG. 20] A diagram illustrating an example of an interface screen.

[FIG. 21] A flowchart illustrating a processing of a sensor installation information mode according to the third embodiment.

[FIG. 22] A diagram for explaining behavior of a human.

[FIG. 23] A diagram for explaining behavior of a human and a robot when an anomaly has occurred.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0008]

<<First Embodiment>>

A behavior detection system S according to a first embodiment is described below with reference to FIG. 1 to FIG. 18.

FIG. 1 is a schematic block diagram illustrating a configuration of the behavior detection system S.

[0009]

As illustrated in FIG. 1, the behavior detection system S includes a plurality of sensor devices 1, a mobile robot 2, a power feed device 3, and a behavior detection server 4.

The sensor device 1: is installed indoors; senses information therein; and transmits the sensed information to the outside via a communication part 14. The mobile robot 2: includes a detection part 22 and a mechanical part 23; and can move around in a room. The mobile robot 2 is, for example, a robot capable of cleaning a floor. The mobile robot 2 is not, however, limited to this and may be a pet robot, a security robot, or the like.

[0010]

The power feed device 3 supplies power to the mobile robot 2. A control part 41 of the behavior detection server 4 includes a communication part 44 which communicates with a plurality of the sensor devices 1 and the mobile robot 2. The control part 41 detects a behavior and/or a state of a mobile entity such as a human, an animal, and any other robot device, based on information detected by the sensor devices 1 or the mobile robot 2 in communication with the communication part 44.

[0011]

Each of a plurality of the sensor devices 1: includes a control part 11, a detection part 12 (a first sensor), a storage part 13, a communication part 14 (a first communication part), and a power supply part 15; and is installed in a living space 9 illustrated in FIG. 2.

The power supply part 15 activates the sensor device 1 and supplies power to respective parts thereof. The communication part 14: is a wired or wireless

communication module; and transmits information detected by the sensor device 1 and a unique ID (IDentifier) of the sensor device 1 of interest, to the behavior detection server 4. The storage part 13: is, for example, a ROM (Read Only Memory) or a flash memory: and stores therein the unique ID of the sensor device 1 or the like. The detection part 12 which may also be referred to as a first sensor detects information in a room or the like. The detection part 12: is, for example, a human detecting sensor that detects a human or the like by infrared, ultrasound, or the like; and can detect a mobile entity such as a human and a mobile robot. The control part 11 controls an operation of the detection part 12.

[0012]

The mobile robot 2 includes a power supply part 25, a mechanical part 23 (a traveling part), a detection part 22 (a second sensor), a control part 21, a storage part 24, a communication part 27 (a second communication part), and an operation part 26. The mobile robot 2 is equipped with a secondary battery (not illustrated) in the power supply part 25. Charging the secondary battery with the power feed device 3 makes the mobile robot 2 operate.

[0013]

The power supply part 25: activates the mobile robot 2; and supplies power to respective parts thereof. The mechanical part 23: is used for traveling in a room; and is composed of, for example, a motor and one or more wheels. The mechanical part 23 serves as a traveling part which can make the mobile robot 2 travel in the living space 9.

[0014]

The detection part 22 which may also be referred to as a second sensor detects information in a room. The detection part 22 includes a group of sensors, each of which detects a location of the mobile robot 2 or an operation of a mobile entity such as a human and an animal. The control part 21: is, for example, a CPU (Central Processing Unit); analyzes information detected by the detection part 22; and

controls an operation of the mobile robot 2, based on the analyzed detection information. The storage part 24: is, for example, a RAM (Random Access Memory) or a flash memory; and stores therein the information analyzed by the control part 21. The communication part 27: is, for example, a Wi-Fi (registered trademark) communication module; and allows information to be received and transmitted between the control part 21 and the behavior detection server 4. The operation part 26: is, for example, a switch or a button; and is used for operating the mobile robot 2 by a user.

[0015]

The power feed device 3 supplies power to the mobile robot 2. The power feed device 3 includes a detection part 31 and a communication part 32. The detection part 31 is a sensor which detects a location of the mobile robot 2. The communication part 32: is, for example, a Wi-Fi (registered trademark) communication module; and allows information to be received and transmitted between the control part 21 and the behavior detection server 4.

[0016]

The detection part 22 of the mobile robot 2 includes: a group of sensors, each of which may be an infrared, an ultrasonic, a laser, an acceleration, or a speech recognition sensor, a camera, or the like; and another group of sensors, each of which detects an operation of the mechanical part 23. The detection part 22 is a part for detecting geometric information on a space in which the mobile robot 2 itself travels; includes a location sensor; and allows the mobile robot 2 travel in a room of interest. The control part 21 can recognize a self-location using the information on operation of the mechanical part 23 and the information detected by the group of sensors. Thus, the control part 21 of the mobile robot 2: makes the detection part 22 analyze the geometric information in the living space 9; and then makes the storage part 24 store therein the analyzed geometric information (a living space map). This makes it possible for the control part 21 to recognize a self-location of the mobile

robot 2 itself. Upon receipt of information on a destination (geometric information) from the communication part 27, the mobile robot 2 can travel to the destination.

[0017]

The control part 21 of the mobile robot 2 can transmit space information (GI) on a self-location thereof to the behavior detection server 4 via the communication part 27. The control part 21 of the mobile robot 2 includes therein a recognition part not illustrated that recognizes behavior of a mobile entity such as a human and an animal, which is detected by the detection part 22 by means of an image or a speech. The control part 21 of the mobile robot 2 can thus transmit information on a state of the detected mobile entity to the behavior detection server 4 via the communication part 27. Upon receipt of the state information, the control part 41 of the behavior detection server 4 can transmit the state information to the outside via an external communication part 45.

[0018]

The behavior detection server 4 includes a control part 41, a storage part 42, a timer 43, a communication part 44 (a third communication part), and an external communication part 45. The communication part 44: is, for example, a Wi-Fi (registered trademark) communication module; receives information transmitted from the sensor device 1 or the mobile robot 2; and transmits information to the mobile robot 2. The communication part 44 which may also be referred to as the third communication part can communicate with a plurality of the sensor devices 1 or the mobile robot 2 disposed indoors.

[0019]

The external communication part 45: is, for example, a network interface card (NIC); and transmits and receives information to and from an external network other than the one constructed by the sensor device 1 and the mobile robot 2. The control part 41: analyzes information received from the sensor device 1, the mobile robot 2, and the external communication part 45; and controls the mobile robot 2 based on a

result of the analysis. The control part 41 serves as a control part that detects behavior of a mobile entity, based on sensor information detected by a plurality of the sensor devices 1 (first detection information) and information detected by the detection part 22 of the mobile robot 2 (second detection information).

[0020]

The storage part 42 stores therein input information from the external communication part 45 or control information of the control part 41. The storage part 42 stores therein: sensor position information showing a position at which each of a plurality of the sensor devices 1 is installed; and a correspondence relationship between geometric information on a space in which the mobile robot 2 has traveled and information on the position at which each of a plurality of the sensor devices 1 is installed. The control part 41 stores, in the storage part 42, a position at which each of the sensor devices 1 is installed, as location information represented in a coordinate system of a space detected by the location sensor of the mobile robot 2. The timer 43 recognizes a time at which an event occurs.

Each of functions performed by the behavior detection server 4 may be incorporated in the mobile robot 2 or the sensor device 1.

[0021]

FIG. 2 is a diagram illustrating the living space 9 in which the behavior detection system S is established according to the first embodiment.

The living space 9 is, for example though not limited to, an inside of a house and may be otherwise an office room, a warehouse, or the like. The living space 9 includes seven sensor devices 1-1 to 1-7, and the power feed device 3. The mobile robot 2 travels around the living space 9 on a route shown by a thick arrow.

Respective locations of the mobile robot 2 and a human at each of event times Et1 to Et8 are indicated on the route shown by the thick arrow.

[0022]

A living room in the living space 9: has the sensor devices 1-7, 1-1, and 1-2;

and also has the power feed device 3 near the the sensor device 1-7. A kitchen has the sensor device 1-3. A dining room behind the kitchen has the sensor device 1-4. A corridor at a base of steps has the sensor device 1-5. An entrance has the sensor device 1-6. Note that when any one of the sensor devices 1-1 to 1-7 is described without specifically distinguishing one from the others, the any one of the sensor devices 1-1 to 1-7 may be simply and collectively referred to as the sensor device 1.

[0023]

The sensor device 1-7 has a unique ID of NS7. The sensor device 1-7 has a feature space NR7 which is: an area detected thereby; and covers a left portion of the living room with respect to the plane of FIG. 2, as shown by a broken line.

The sensor device 1-1 has a unique ID of NS1. The sensor device 1-1 has a feature space NR1 which: is an area detected thereby; and covers a central portion of the living room with respect to the plane of FIG. 2, as shown by a broken line.

[0024]

The sensor device 1-2 has a unique ID of NS2. The sensor device 1-2 has a feature space NR2 which: is an area detected thereby; and covers a right portion of the living room with respect to the plane of FIG. 2, as shown by a broken line.

The sensor device 1-3 has a unique ID of NS3. The sensor device 1-3 has a feature space NR3 which: is an area detected thereby; and covers the kitchen as shown by a broken line.

[0025]

The sensor device 1-4 has a unique ID of NS4. The sensor device 1-4 has a feature space NR4 which: is an area detected thereby; and covers the dining room as shown by a broken line.

The sensor device 1-5 has a unique ID of NS5. The sensor device 1-5 has a feature space NR5 which: is an area detected thereby; and covers the corridor as shown by a broken line.

The sensor device 1-6 has a unique ID of NS6. The sensor device 1-6 has a

feature space NR6 which: is an area detected thereby; and covers the entrance as shown by a broken line.

[0026]

As described above, each of a plurality of the sensor devices 1-1 to 1-7 disposed in the living space 9 can transmit detection information (SD) detected by the sensor device 1 of interest itself with a unique ID (NS) thereof added thereto, to the behavior detection server 4.

[0027]

FIG. 3 is a diagram illustrating an example of sensor installation information (SI).

The behavior detection server 4 includes the storage part 42. The storage part 42 previously stores therein sensor installation information (SI) which shows a relationship between each of the unique IDs (NR1 to NR7) of the feature spaces in the living space 9 and each of the unique IDs (NS) of the sensor devices 1 installed therein.

The sensor installation information (SI) can additionally store therein geometric information (GI) which is information relevant to detection area information (RS). The control part 41 of the behavior detection server 4 has the timer 43, based on which the sensor installation information (SI) can additionally store therein a time when a data (NS_i, SD_i) on the sensor device 1 is received, as an event occurrence time (Et).

[0028]

FIG. 4 is a diagram illustrating an example of event information (EI).

The event information (EI) illustrated in FIG. 4 can be stored and held as data relevant to detection of behavior of a human. The event information (EI) is managed as data for each sensor unique ID (NS). The event information (EI) stores and holds therein an ID (NR_j) of each of the feature spaces in the living space 9, data (SD) of each of the sensor devices 1, and the event occurrence time (Et). Note that, as illustrated in FIG. 3, the feature space (NR) and the sensor ID (NS) may or may not

correspond one-to-one with each other.

[0029]

How the space information (GI) is added to the sensor installation information (SI) will be described with reference to respective flowcharts of FIG. 7 and FIG. 8. FIG. 5 is a diagram illustrating outlines of operations of the sensor device 1 and the mobile robot 2, when sensor installation information is created. FIG. 6 is a diagram illustrating detection information of each of the sensors (NSi) on a time-series basis. As illustrated in FIG. 5 and FIG. 6, when the behavior detection server 4 receives data showing a sensor installation information creation mode via the external communication part 45, the control part 41 of the behavior detection server 4 sets a sensor installation information flag Sf. When the sensor installation information flag Sf is set, the control part 41 of the behavior detection server 4 transmits a start signal to the mobile robot 2. After the mobile robot 2 has started, the control part 41 stands by for a response from the sensor device 1 or the mobile robot 2.

[0030]

As the mobile robot 2 travels along the arrow illustrated in FIG. 5, the sensor device 1-7 (NS7), the sensor device 1-1 (NS1), ..., the sensor device 1-6 (NS6), and the sensor devices 1-7 (NS7) respond thereto in this order.

[0031]

As illustrated in FIG. 6, the control part 41 of the behavior detection server 4 receives sensor detection data (NSi, SDi) for each of responses from the sensor devices 1. Upon receipt of the sensor detection data (NSi, SDi), the control part 41: acquires an event occurrence time (Et) from the timer 43; and requests the mobile robot 2 to send a self-location thereto.

[0032]

The mobile robot 2: includes therein the detection part 22 that detects a self-location thereof with respect to the power feed device 3; and can thereby recognize the self-location in a coordinate system of FIG. 5. Upon the request, the control part

21 of the mobile robot 2 makes the detection part 22 measure a coordinate (X, Y) which is a location of the power feed device 3 as an origin, and an absolute distance R between the mobile robot 2 and the power feed device 3. The control part 21 then transfers the measured coordinate (X, Y) and the measured absolute distance R to the behavior detection server 4.

[0033]

As illustrated in FIG. 7, the control part 41 of the behavior detection server 4 identifies, based on the received sensor detection data (NSi, SDi), a unique ID of the sensor device 1 which has detected the data. The control part 41 reads information on coordinates of areas detected by the sensor device 1 having the sensor unique ID of interest in the sensor installation information (SI). The detection area coordinate information includes: a minimum value Rmin and a maximum value Rmax of the absolute distance R; a minimum value Xmin and a maximum value Xmax of the coordinate X; and a minimum value Ymin and a maximum value Ymax of a coordinate Y.

[0034]

The control part 41 compares the read detection area information with the coordinate data (GI (R, X, Y)) received from the mobile robot 2 (S10). The control part 41 determines whether or not the following Formula (1) and Formula (2) hold; and thereby determines a range of a response (S11). The control part 41 thereby: updates the detection area information (Rmax, Rmin, Xmin, Xmax, Ymax, Ymin); and adds appropriate geometric information to the sensor installation information (SI) (S12).

[Formula 1]

$$| R - R_{\max} | > \varepsilon \quad \cdot \cdot \cdot \quad (1)$$

[0035]

[Formula 2]

$$| R - R_{\min} | > \varepsilon \quad \cdot \cdot \cdot \quad (2)$$

[0036]

As described above, by associating the detection information by the sensor device 1 with the coordinate information, a detection area of the sensor device 1 can be associated with a space coordinate of a living space map (LS) created by the mobile robot 2.

[0037]

FIG. 8 is a flowchart illustrating a processing of a sensor installation information (GI) mode.

The processing of the sensor installation information mode is performed as described below. Upon receipt of a sensor installation mode, the control part 41 of the behavior detection server 4 sets a sensor installation information flag Sf (S40).

In step S41, the control part 41 of the behavior detection server 4 determines whether or not the mobile robot 2 is in a power fed state. If the mobile robot 2 is determined to be in the power fed state (Yes), the control part 41 of the behavior detection server 4 advances the processing to step S43. If the mobile robot 2 is determined to be in an operating state (No), the control part 41 advances the processing to step S42.

In step S42, the control part 41 of the behavior detection server 4: instructs the mobile robot 2 to travel to a location at which power is fed thereto; and returns the processing back to step S41. The control part 41 then stands by until the mobile robot 2 enters the power fed state.

[0038]

In step S43, the control part 41 of the behavior detection server 4: acquires an event occurrence time (Et) from the timer 43; and acquires sensor detection data (NSi, SDi) from the sensor device 1. The control part 41: holds therein the acquired sensor data as (Et, NSi, SDi); and advances the processing to step S44.

In step S44, the control part 41 of the behavior detection server 4: requests the mobile robot 2 to acquire space information; acquires the space information (GI (R, X, Y)) from the mobile robot 2; and advances the processing to step S45.

[0039]

In step S45, the control part 41 of the behavior detection server 4: brings up sensor installation information regarding a sensor ID (NSi) of a sensor as a target to be detected; and advances the processing to step S451.

In step S451, after loading the detection area information (RS), the control part 41 of the behavior detection server 4 advances the processing to step S46. The loaded detection area information (RS) contains information on (Rmax, Rmin, Xmin, Xmax, Ymax, Ymin).

[0040]

In step S46, the control part 41 of the behavior detection server 4 determines whether or not the detection area information (RS) has received an input of a detected value and stores therein the detected value. If it is determined that there is no detection area information (RS) of interest (No), the control part 41 advances the processing to step S48. If it is determined that the detection area information (RS) stores therein the detected value (Yes), the control part 41 advances the processing to step S47.

[0041]

In step S47, the control part 41 of the behavior detection server 4 compares the detection area information (RS) with the space information (GI (R, X, Y)). The control part 41 determines whether or not the space information (GI (R, X, Y)) of the mobile robot 2 stays within a range of the detection area information (RS), that is, within a range having been acquired as the geometric information. If the space information is not determined to be within the range having been acquired as the geometric information (No), the control part 41 of the behavior detection server 4 advances the processing to step S48. If the space information is determined to be within the range having been acquired as the geometric information, the control part 41 of the behavior detection server 4 advances the processing to step S50.

[0042]

In step S48, the control part 41 of the behavior detection server 4: updates the stored detection area information (RS) by replacing the information (RS) with the space information (GI (R, X, Y)) from the mobile robot 2; and advances the processing to step S49.

In step S49, the control part 41 of the behavior detection server 4: calculates a sum of dimensions of searched areas; and advances the processing to step S50.

[0043]

In step S50, the control part 41 of the behavior detection server 4 determines whether or not the sum of the dimensions of the searched areas is the same as a total of dimensions of searched spaces. If it is determined that the sum of the dimensions of the searched areas is the same as the total of the dimensions of the searched spaces (Yes), the control part 41 of the behavior detection server 4 advances the processing to step S51. If it is not determined that the sum of the dimensions of the searched areas is the same as the total of the dimensions of the searched spaces (No), the control part 41 of the behavior detection server 4 returns the processing back to step S41.

In step S51, the control part 41 of the behavior detection server 4 clears the sensor installation information flag Sf, to thereby terminate the sensor installation information mode.

[0044]

By using the above-described sensor installation information (SI), the control part 41 of the behavior detection server 4 detects a response of the sensor device 1 to the mobile robot 2, and a response of the sensor device 1 to a mobile entity such as a human and an animal, separately from each other. The control part 41 can thus store the detection information by the sensor device 1 concerning behavior of the mobile entity, as event information (EI). How to separate information detected by the sensor device 1 into data on behavior of a mobile entity and the other data will be described later with reference to respective flowcharts illustrated in FIG. 11, FIG. 13,

and FIG. 14.

[0045]

FIG. 9 illustrates an outline of responses of the sensor devices 1 when both the mobile robot 2 and a person are moving in the living space 9.

The living space 9 is equipped with the seven sensor devices 1-1 to 1-7 and the power feed device 3. The mobile robot 2 is traveling therein by a route indicated by a thick arrow. Positions of the mobile robot 2 at respective event times Et1 to Et8 are shown on the route indicated by the thick arrow. The route of the mobile robot 2 illustrated in FIG. 9 is different from that illustrated in FIG. 2. This is because the sensor installation information mode has already been completed and shifted to an event information mode.

[0046]

FIG. 10 is a diagram illustrating time-series detection information detected by a sensor device of interest (NSi).

As illustrated in FIG. 10, each time the mobile robot 2 travels, the sensor device 1 responds at each event time. That is, at event time Et1, the sensor device 1-7 (NS7) responds. At event time Et2, the sensor device 1-1 (NS1) responds. At event time Et3, the sensor device 1-2 (NS2) responds. At event time Et4, the sensor device 1-3 (NS3) responds. At event time Et5, the sensor device 1-4 (NS4) responds. At event time Et6, the sensor device 1-5 (NS5) responds. At event time Et7, the sensor device 1-6 (NS6) responds. And, at event time Et8, the sensor devices 1-7 (NS7) responds.

[0047]

Similarly, when a person of interest moves, at event time Et3, the sensor device 1-5 (NS5) responds. And, at event time Et4, the sensor device 1-6 (NS6) responds.

[0048]

As illustrated in FIG. 11, each time the control part 41 of the behavior detection

server 4 receives detection information from the sensor device 1-i (NSi), the control part 41 receives space information (GI (R, X, Y)) on a self-location of the mobile robot 2. The control part 41 then compares the detection area (RS) stored in the sensor installation information (SI), with the space information (GI (R, X, Y)) (S20). Based on a result of the comparison, the control part 41: creates event information (EI) in which data generated from a response to a travel of the mobile robot 2 is distinguished from the other data (S21); and stores the created event information (EI) in the storage part 42 (S22).

[0049]

FIG. 12 is a graph illustrating only the event information (EI) extracted from the detection information.

As illustrated in FIG. 12, at event time Et3, the sensor device 1-5 (NS5) responds. At event time Et4, the sensor device 1-6 (NS6) responds. Each of the information acquired herein is information on detection of a human, an animal, or the like, that is, the detection information excluding information on detection of the mobile robot 2. The control part 41 can detect behavior of a mobile entity such as a human and an animal as described above.

[0050]

In the aforementioned event information mode, a processing is performed as illustrated in FIG. 13 and FIG. 14.

FIG. 13 is a flowchart illustrating a processing performed when, in the event information (EI) mode, the mobile robot 2 is not started.

[0051]

In the event information (EI) mode, in step S60, the control part 41 of the behavior detection server 4: receives sensor detection information (NSi, Et, SD) from the sensor device 1; and advances the processing to step S61.

In step S61, the control part 41 of the behavior detection server 4 determines whether or not the mobile robot 2 has been started. If the mobile robot 2 is not

determined to have been started (No), the control part 41 advances the processing to step S62. If the mobile robot 2 is determined to have been started (Yes), the control part 41 advances the processing to step S70 which is illustrated in FIG. 14.

[0052]

In step S62, the control part 41 of the behavior detection server 4 determines whether or not the processing is in a sensor installation information mode. If the sensor installation information flag Sf has been set, the control part 41: determines that the processing is in the sensor installation information mode; and returns the processing back to step S60. If the sensor installation information flag Sf is determined to have been cleared, the control part 41 advances the processing to step S63.

[0053]

In step S63, the control part 41 of the behavior detection server 4: acquires data having been acquired by a sensor of interest (NSi), from the event information (EI); and advances the processing to step S631.

In step S631, the control part 41 of the behavior detection server 4: reads the data having been acquired by the sensor of interest from the event information (EI); and advances the processing to step S64.

In step S64, the control part 41 of the behavior detection server 4: calculates a comparative data, based on the having-been-acquired data; and advances the processing to step S65. The control part 41 calculates the comparative data by, for example, averaging one or more pieces of detection information (NSi, Et, SD) having been received.

[0054]

In step S65, the control part 41 of the behavior detection server 4 compares the detection information (NSi, Et, SD) with the comparative data (CD). If a difference therebetween is larger than a threshold ε_1 (Yes), the control part 41: determines that a behavior different from a normal one has been detected; and advances the

processing to step S67. In step S67, the control part 41: switches a mode of a state of the processing to an anomaly mode; and sets an anomaly mode flag EMf to "1".

If the difference is equal to or smaller than the threshold ε_1 (Yes), the control part 41 of the behavior detection server 4 determines that the detected behavior belongs to a normal state; and adds the detection information thereon to the event information (EI) (S66). The control part 41 then returns the processing back to step S60.

[0055]

FIG. 14 is a flowchart illustrating a processing performed when, in the event information (EI) mode, the mobile robot 2 has already started.

In step S70, the control part 41 of the behavior detection server 4 determines whether or not the processing is in an anomaly processing mode, by determining whether or not an anomaly mode flag EMf has been set. If the processing is determined to be in the anomaly processing mode (Yes), the control part 41 shifts the mode of the processing to an anomaly mode as illustrated in FIG. 17. If the processing is not determined to be in the anomaly processing mode (No), the control part 41 advances the processing to step S71.

[0056]

In step S71, the control part 41 of the behavior detection server 4 determines whether or not the processing is in a sensor installation information mode. If the sensor installation information flag Sf has been set (Yes), the control part 41: determines that the processing is in the sensor installation information mode; and returns the processing back to step S60. If the sensor installation information flag Sf is determined to have been cleared (No), the control part 41 advances the processing to step S72.

[0057]

In step S72, the control part 41 of the behavior detection server 4 acquires self-location information GI (R, X, Y) from the mobile robot 2. The control part 41: acquires

the self-location information GI (R, X, Y) from the mobile robot 2; and advances the processing to step S73.

[0058]

In step S73, the control part 41 of the behavior detection server 4 identifies which detection information is that of the sensor device 1 which has responded to the mobile robot 2, based on the self-location information GI (R, X, Y) of the mobile robot 2 and the sensor installation information (SI). The control part 41 then: determines that detection information from the sensor devices 1 other than that of the sensor device 1 having responded to the mobile robot 2 is behavior detection information (MI) on a mobile entity such as a human and and an animal; and advances the processing to step S74.

[0059]

In step S74, the control part 41 of the behavior detection server 4 requests a data for comparing with the behavior detection information (MI), from the event information (EI).

In step S741, the control part 41: acquires the requested data; and advances the processing to step S75.

[0060]

In step S75, the control part 41 of the behavior detection server 4: calculates a comparative data (CD), based on the data acquired from the event information (EI); and advances the processing to step S76.

In step S76, the control part 41 of the behavior detection server 4 compares the behavior detection information (MI) with the comparative data (CD). If a result obtained by the comparison is larger than a threshold ε_2 (Yes), the control part 41 of the behavior detection server 4: determines that a detected behavior of interest belongs to an anomaly state; advances the processing to step S78; switches the mode of the state of the processing to an anomaly mode; and sets the anomaly mode flag EMf to "1". If the result is equal to or smaller than the threshold ε_2 (No), the

control part 41 advances the processing to step S77.

[0061]

In step S77, the control part 41 of the behavior detection server 4: adds the behavior detection information (MI) to the event information (EI); and returns the processing back to step S60.

The control part 41 of the behavior detection server 4, which has switched the mode of the processing to the anomaly mode performs processings described below as illustrated in FIG. 15 to FIG. 17 and FIG. 18.

[0062]

FIG. 15 is a diagram illustrating a case in an anomaly state in which NS6 (the sensor device 1-6) has no response between a time period Et4-Et5, though NS5 (the sensor device 1-5) has an ordinary response as a daily behavior (the event information (EI)) between a time period Et3-Et4.

[0063]

FIG. 16 is a diagram illustrating detection information from a sensor device (NSi) on a time-series basis.

As illustrated in FIG. 16, if no sensor has any detection response between the time period Et4-Et5, the control part 41 of the behavior detection server 4 compares the event information (EI) with the detection information (NSi, SD). If a difference between the event information (EI) and the detection information (NSi, SD) is larger than a prescribed threshold, the control part 41: determines that an anomaly behavior has occurred; and transmits, to the mobile robot 2, sensor installation information (SI (R, X, Y)) requesting that the mobile robot 2 travel to NSi which has detected the anomaly behavior. If the event information (EI) is determined to be the same as the detection information (NSi, SD), the control part 41 of the behavior detection server 4 continues detection.

[0064]

An anomaly detection mode described above is performed as follows as

illustrated in FIG. 17.

In step S80, the control part 41 of the behavior detection server 4: requests a self-location ($G_l(R, X, Y)$) from the mobile robot 2; thereby acquires a current location of the mobile robot 2; and advances the processing to step S81.

In step S81, the control part 41 of the behavior detection server 4 performs one of options in a multiple branch in accordance with a type of the anomaly mode flag EMf. If the anomaly mode flag EMf is "1", the control part 41 of the behavior detection server 4 advances the processing to step S82. If the anomaly mode flag EMf is "2", the control part 41 of the behavior detection server 4 advances the processing to step S85. If the anomaly mode flag EMf is "3", the control part 41 of the behavior detection server 4 advances the processing to step S87.

[0065]

In step S82, the control part 41 of the behavior detection server 4: transmits data showing that the processing is in an anomaly state diagnosis mode, to the mobile robot 2; and also transmits a target coordinate $G_{lo}(N_{Si}, R, X, Y)$ and a passage estimation sensor (PS) to the mobile robot 2 (S83). The control part 41: sets the anomaly mode flag EMf to "2" (S84); and shifts the mode of the processing to the event information mode.

[0066]

In step S85, the control part 41 of the behavior detection server 4: compares the self-location (G_l) of the mobile robot 2 and the target coordinate (G_{lo}); and thereby determines whether or not the mobile robot 2 is present in an area in which the mobile robot 2 itself is to search possible anomaly. If a difference between the self-location (G_l) and the target coordinate (G_{lo}) is smaller than the threshold ϵ_3 (No), the control part 41: determines that the mobile robot 2 has already traveled to the anomaly search area; changes the anomaly mode flag EMf to 3 (S86); and shifts the mode of the processing to the event information mode. If the difference between the self-location (G_l) and the target coordinate (G_{lo}) is equal to or larger than the

threshold ε_3 (Yes), the control part 41: determines that the mobile robot 2 has not yet reached the anomaly search area; and shifts the mode of the processing to the event information mode.

[0067]

In step S87, the control part 41 of the behavior detection server 4: determines that the processing is in an anomaly search mode; and determines whether or not there is any anomaly. Whether or not there is any anomaly may be determined by using, for example, an image from an image sensor and a voice from a voice sensor each installed in the detection part 22 of the mobile robot 2. In step S87, if any anomaly has been detected (Yes), the control part 41: advances the processing to step S88; creates a report on the detected anomaly; notifies an external service via the external communication part 45 of the behavior detection server 4 that the anomaly has been detected (S88); and shifts the processing to the event information mode.

[0068]

In step S87, if any anomaly has not been detected (No), the control part 41: advances the processing to step S89; creates a report on the search of anomaly; and transmits the search report to the external service via the external communication part 45 of the behavior detection server 4. After transmitting the search report, the control part 41 of the behavior detection server 4: advances the processing to step S90; resets the anomaly diagnosis mode (S90); and shifts the processing to the event information mode.

[0069]

The behavior detection system S of the present invention makes a plurality of the sensor devices 1 disposed in the living space 9 coordinate with the mobile robot 2 having the traveling part for traveling in the living space 9. This makes it possible for the behavior detection system S to prevent false information from being delivered, which may be otherwise caused by malfunction of the sensor device 1, and to secure

a user's privacy.

[0070]

<<Second Embodiment>>

FIG. 18 is a schematic block diagram illustrating a configuration of a behavior detection system according to a second embodiment of the present invention. In the second embodiment: in place of a plurality of the sensor devices 1, a plurality of household electrical appliances 8 are disposed in a living space; and in place of detection information by the sensor devices, information on an operation of the household electrical appliance or information detected thereby is detected, to thereby a behavior of a human is detected. A plurality of the household electrical appliances 8 each have various functions as the respective household electrical appliances, in addition to the functions performed by the sensor devices 1 in the first embodiment.

[0071]

As illustrated in FIG. 18, the behavior detection system S includes a plurality of the household electrical appliances 8, the mobile robot 2, the power feed device 3, and the behavior detection server 4.

The household electrical appliance 8: is disposed in a living space; performs functions of various types; and is, for example, a television, a lighting fixture, and an air conditioner. The household electrical appliance 8 transmits, to the outside, operation information which is information on operation of the operated household electrical appliance 8 itself, via the communication part 44.

[0072]

Each of a plurality of the household electrical appliances 8 includes a control part 81, a detection part 82, a storage part 83, a communication part 84, a power supply part 85; and a wireless tag 86. The power supply part 85: starts the household electrical appliance 8 itself; and supplies power to appropriate components thereof. The communication part 84: is a wireless or a wired communication module; and transmits information on operation of the household electrical appliance 8 itself and a

unique ID thereof to the behavior detection server 4. The storage part 83: is, for example, a ROM or a flash memory; and stores therein the unique ID of the household electrical appliance 8.

[0073]

<<Third Embodiment>>

Each of the first embodiment and the second embodiment assumes that each of the sensor devices 1 is fixed in a prescribed position. In many cases, however, the position and/or the number thereof and/or a space monitored therewith changes due to extension and/or alteration of a space of interest or a change in usage of the space. Even with such a change(s) described above, in the behavior detection system according to the first (or the second) embodiment, sensor installation information (SI) and event information (EI) can be created, to each of which the positions and/or the number of the sensor devices 1 after the change are reflected, by appropriately operating the robot 2. This means that the behavior detection system according to the first (or the second) embodiment can also create a correspondence relationship between a position of the sensor device 1 and geometric information of a space in which the robot 2 has traveled.

[0074]

It is nevertheless possible for a user to: manually enter a part of initial values of the sensor installation information (SI); and, when the user changes one or more positions, the number, or the like of the sensor devices 1 after that, again manually enter appropriate data after the change, into the sensor installation information (SI). Some users may prefer flexible manual data entry even with some extra work added, because, by doing so, they feel a sense of security in how the behavior detection system works after the change (for example, a timely arrival of the robot 2 at a scene of interest, when an anomaly occurs). Thus, a behavior detection system S according to the third embodiment further includes an interface device 6, in addition to the sensor device 1, the robot 2, and the behavior detection server 4. With addition of the

interface device 6 as a new element, a configuration of the sensor installation information (SI) is partly changed from that according to the first (or the second) embodiment (details of which will be described hereinafter).

[0075]

FIG. 19 is a schematic block diagram illustrating a configuration of the behavior detection system S according to the third embodiment. The behavior detection system S includes the interface device 6. The interface device 6: is, for example, a mobile computer; and is operated by a user in a room or the like. The interface device 6 includes: a control part 61; a display part 62 such as a display; an input part 63 such as a keyboard, a mouse, and a touch panel; a storage part 66; a communication part 65 for communicating with the behavior detection server 4 or the like; and a power supply part 64. The storage part 66 stores therein sensor installation information (SI) or the like. The power supply part 64 supplies power received from an external power source 5 to the control part 61 or the like.

[0076]

FIG. 20 illustrates an example of an interface screen 71 which is displayed by the display part 62 of the interface device 6. A living space map (LS) is displayed in a section 72 of the interface screen 71; and, sensor installation information (SI), in a section 73 thereof. The living space map (LS) displayed herein is the same as that of the living space 9 illustrated in FIG. 2, except that:

- The living space map (LS) is entirely segmented by grids (broken lines); and
- The living space map (LS) illustrates a state in which, compared to FIG. 2, though the sensor devices NS1 and NS7 are similarly disposed therein, the sensor device NS2 is not yet installed in the living room.

[0077]

The sensor installation information (SI) displayed herein is the same as the sensor installation information (SI) described with reference to FIG. 3, except that:

- In place of a column of the event occurrence time (Et) of the sensor installation

information (SI) in FIG. 3, the sensor installation information (SI) in FIG. 20 has respective columns of a type of a sensor (Type), an ID of the sensor (ID), and a detection area (Area).

[0078]

The type of a sensor is a type (infrared, ultrasonic, or the like) of the detection part 12 of the sensor device 1.

The detection area: means a size of a space, which, if a human or the like is present in the space, the person or the like can be detected by a single unit of interest of the sensor devices without fail; and is herein a floor area of the space. The detection area as "Spot" shows that definition of an area of a space of interest is impossible (for example, a lock at an entrance or the like).

[0079]

It is assumed herein a user has the following under consideration:

- It is required to add a new sensor device NS2 on the right portion of the living room;
- A sensor type of the sensor device NS2 is "Oc";
- A detection area of the sensor device NS2 corresponds to approximately 16 grid squares on the living space map (LS); and
- The detection area of the sensor device NS2 is to be managed as "NR2".

[0080]

The user: selects the 16 grid squares using the input part 63 such as a mouse; and puts both an icon indicating "NR2" and an icon indicating "NS2" into the selected area. The icon indicating "NS2" is linked with a sensor ID and a type of a sensor device of interest. The control part 61 of the interface device then: creates a new record 74 of the sensor installation information (SI); and displays the created record 74 in the section 73 on the interface screen 71.

[0081]

The above-described is an example assuming that a sensor device is newly added. In another example, data on a plurality of sensor devices is inputted at one

time, when, for example, the behavior detection system S is used for the first time (an input of sensor initial information). At the time of the initial input, however, the living space map (LS) does not yet exist. The user thus does not use an icon or the like but directly enters an appropriate character string or the like to the sensor installation information (SI). In those cases described above, the flowchart (FIG. 8) of the sensor installation information mode according to the first embodiment is partly changed.

[0082]

FIG. 21 is a flowchart illustrating a processing of a sensor installation information mode according to the third embodiment. FIG. 21 is the same as FIG. 8, except that: FIG. 21 additionally includes step S40b; and, in place of step S43, S44, and S45 in FIG. 8, FIG. 21 includes steps S43b, S44b, and S45b, respectively. Description below is made focusing on those steps S40b, S43b, S44b, and S45b.

[0083]

In step S40b, the control part 61 of the interface device 6 allows an input of sensor initial information (NS, Type, ID, Area). More specifically, the control part 61: displays the section 73 of the interface screen 71 in the display part 62; and allows entry of data from a user via the input part 63, into each of columns of the NS, Type, ID, and Area. The user similarly enters data on all of the other sensor devices 1. The control part 61 stores records of all of the sensor devices 1 in the storage part 66 as sensor installation information (SI).

[0084]

In step S43b, the control part 61 of the interface device 6 requests space information from the mobile robot 2. More specifically, the control part 61 requests space information (GI (R, X, Y)) from the mobile robot 2.

[0085]

In step S44b, the control part 61 of the interface device 6: acquires the space information from the mobile robot 2; and allows an input of a change in a position of the sensor device 1 of interest from the user. More specifically, firstly, the control part

61 acquires the space information (GI (R, X, Y)) from the mobile robot 2.

Secondly, the control part 61: displays the living space map (LS) in the section 73 on the interface screen 71, using the space information acquired in the “first part” of step S44b; and prompts the user to enter data on the sensor device 1 of which position has changed. In response, as described above, the user enters data on the changed position of the sensor device 1, on the living space map (LS) displayed in the section 72.

[0086]

In step S45b, the control part 61 of the interface device 6 defines a detection area for each NS. More specifically, the control part 61 displays a record corresponding to the data inputted in the “second part” of step S44b, in the section 74 on the interface screen 71. The control part 61 stores the record after the change, as part of the sensor installation information (SI), in the storage part 66.

[0087]

(Behavior of Human and Robot)

FIG. 22 is a diagram for explaining behavior of a human. A residential space map 81 is assumed herein which includes a living room 1, a toilet 5, and a bathroom 8, which are connected each other by a corridor 2, a corridor 3, a corridor 4, a corridor 6, or a corridor 7. Those rooms or the like 1 to 8 described above correspond to the sensor devices NS_i ($i = 1, 2, \dots, 8$), respectively. Note that the reference numerals (1, 2, ...) of the rooms or the like are herein designated for purpose of explanation only in FIG. 22 and are not relevant to those in FIG. 1. A chart 82 illustrates a detected result of behavior of a person in a day by the sensor device NS_i. The chart 82 has time as an abscissa, and, unique IDs (NS_i) of the sensor devices 1 as an ordinate. When any of the sensor devices 1 detects the person, a “chart line (a bold solid line)” of the sensor device 1 of interest takes on a convex shape during a time period during which the person has been detected.

[0088]

After the sensor devices 1 repeat detection as described above a number of times, a “pattern” of behavior of a person at normal times is found on the chart 82. For example, a pattern 1 is a combination of a chart line indicating a behavior of the person moving from the living room 1 to the toilet 5 and another line indicating a behavior returning to the living room 1. The pattern 1 appears, for example, several times a day periodically. A duration of the convex-shaped time for each of NS1, NS2, NS3, NS4, and NS5 is approximately the same every time.

[0089]

A pattern 2 is a combination of a chart line indicating a behavior the person moving from the living room 1 to the bathroom 8 and another line indicating a behavior returning to the living room 1. The pattern 2 appears, for example, once a day at night periodically. A duration of the convex-shaped time for each of NS1, NS2, NS3, NS4, and NS5 is approximately the same every time.

[0090]

FIG. 23 is a diagram for explaining behavior of a human and a robot when an anomaly occurs. Focusing on a pattern 1b in the figure, a duration of a convex-shaped time of a chart line of the corridor 3 (NS3) is significantly longer than that in FIG. 22. The control part 41 of the behavior detection server 4: thereby determines that an anomaly has occurred at a time t1; and transmits an appropriate target coordinate Glo to the robot 2. In response, the robot 2 travels to where the person is highly likely to have fallen down (the corridor 3).

[0091]

Focusing on a pattern 1c, immediately after an ordinary duration of a convex-shaped time of a chart line of the corridor 4 (NS4) is shown, no NSi shows a convex-shaped line. The control part 41 of the behavior detection server 4: thereby determines that an anomaly has occurred at a time t2; and transmits an appropriate target coordinate Glo to the robot 2. In response, the robot 2 travels to where the person is highly likely to have been abducted (the corridor 4).

[0092]

Focusing on a pattern 2b, a duration of a convex-shaped time of a chart line of the bathroom 8 (NS8) is significantly longer than that in FIG. 22. The control part 41 of the behavior detection server 4: thereby determines that an anomaly has occurred at a time t_3 ; and transmits an appropriate target coordinate G_{lo} to the robot 2. In response, the robot 2 travels to where the person is high likely to have fallen unconscious (the bathroom 8).

[0093]

(Variations)

The present invention is carried out not only by the above-described embodiments but also by variations of many types. For example, the above-described embodiments are intended to be illustrative of the present invention in an easily understandable manner and the present invention is not limited to any of the embodiments including all of the components explained in the embodiments. Part of a configuration of an embodiment of the present invention may be substituted by or added to that of another. Part of a configuration of an embodiment may be deleted.

[0094]

A part or all of configurations, features, processing parts, processing units, or the like described above can be realized by hardware by means of, for example, integrated circuits. The above-described configurations, features, or the like can be embodied by software in which, for example, a processor interprets and executes a program which realizes the features or the like. Data in a program, a table, a file, and the like for realizing such features can be stored in a storage device including a memory, a hard disk, and a SSD (Solid State Drive) or in a storage medium including a flash memory card and a DVD (Digital Versatile Disk).

[0095]

In each of the embodiments, only a control line or an information line which is deemed necessary for explanation is illustrated, and not all of them which are

necessary for a product are illustrated. In practice, almost all elements are deemed to be connected to each other.

Variations of the present invention are, for example, (a) to (e) described below.

[0096]

(a) The mobile robot 2 may perform a processing of the event information mode or the anomaly mode, without providing the behavior detection server 4.

(b) Each of the sensor devices 1 may autonomously perform a processing of the event information mode or the anomaly mode, without providing the behavior detection server 4.

(c) The communication part 44 and the external communication part 45 of the behavior detection server 4 may be integrally provided as a single unit.

(d) The mobile robot 2 according to the first embodiment may be equipped with a wireless tag, and the sensor device 1 may detect the wireless tag. This further makes sure that the sensor device 1 detects the mobile robot 2.

(e) Even after a sensor installation information mode has been completed, when a change in a sensor position is detected, sensor position information stored in the storage part may be changed accordingly.

DESCRIPTION OF REFERENCE NUMERALS

[0097]

S behavior detection system

1, 1-1 to 1-7 sensor device

11 control part

12 detection part (first sensor)

13 storage part

14 communication part (first communication part)

15 power supply part

2 mobile robot

21 control part

- 22 detection part (second sensor)
- 23 mechanical part
- 24 storage part
- 25 power supply part
- 26 operation part
- 27 communication part (second communication part)
- 3 power feed device
- 31 detection part
- 32 communication part
- 4 behavior detection server
- 41 control part
- 42 storage part
- 43 timer
- 44 communication part (third communication part)
- 45 external communication part (external communication unit)
- 5 external power source
- 6 interface device
- 61 control part
- 62 display part
- 63 input part
- 64 power supply part
- 65 communication part
- 66 control part
- 8, 8-1 to 8-7 household electrical appliance (sensor device)
- 81 control part
- 82 detection part (first sensor)
- 83 storage part
- 84 communication part (first communication part)

- 85 power supply part
- 9 living space

CLAIMS

[Claim 1]

A behavior detection system, comprising:

a plurality of sensor devices, each of which comprises a first sensor configured to detect information and a first communication part configured to transmit information, and is installed in an indoor space;

a robot that comprises a second sensor configured to detect information, a second communication part configured to receive and transmit information, and a traveling part by which the robot itself travels in the indoor space;

a server that comprises a third communication part configured to receive and transmit information and that is configured to detect behavior of a mobile entity in the indoor space, based on detection information which is information detected by the first sensor of each of a plurality of the sensor devices and another detection information which is information detected by the second sensor of the robot; and

an interface device configured to allow a user to enter, on a screen, data on a position at which each of a plurality of the sensor devices is installed in the indoor space.

[Claim 2]

The behavior detection system according to claim 1,

wherein the robot further comprises a storage part configured to store therein map information on the indoor space, and

wherein the robot is configured to: detect a behavior of the mobile entity, based on the detection information from the first sensor and the detection information from the second sensor; if the behavior is determined to be in a state of anomaly, travel to a position corresponding to a coordinate of interest on the map information, at which the anomaly has been detected; and diagnose the anomaly.

[Claim 3]

The behavior detection system according to claim 2,

wherein each of a plurality of the sensor devices is a household electrical appliance, and

wherein the robot is configured to receive information on an operation of the household electrical appliance.

[Claim 4]

The behavior detection system according to claim 3,

wherein the robot further comprises a location sensor configured to detect geometric information on a space in which the robot itself travels, and

wherein the storage part of the robot is configured to: store therein respective positions at which a plurality of the sensor devices are installed; and also store therein a correspondence relationship between the geometric information on the space in which the robot itself travels and each of the respective positions at which a plurality of the sensor devices are installed.

[Claim 5]

The behavior detection system according to claim 4,

wherein the storage part of the robot stores therein the respective positions at which a plurality of the sensor devices are installed, as location information which is information represented in a coordinate system of a space detected by the location sensor of the robot itself.

[Claim 6]

The behavior detection system according to claim 5,

wherein the robot is configured to: when the second sensor detects information, hold the detected information in the storage part; compare the currently-detected information with information having-been-previously held in the storage part; and, based on a result of the comparison, diagnose a possible anomaly state of a behavior of the mobile entity.

[Claim 7]

The behavior detection system according to claim 6,

wherein the robot further comprises: a sensor configured to diagnose details of a possible anomaly; and an external communication part configured to communicate with the outside, and

wherein, if an anomaly is determined to have actually occurred, the robot is configured to transmit information on the anomaly determined to have actually occurred, to the outside via the external communication part.

[Claim 8]

An interface device configured to communicably connect itself to: a plurality of sensor devices, each of which comprises a first sensor configured to detect information and a first communication part configured to transmit information, and is installed in an indoor space; a robot that comprises a second sensor configured to detect information, a second communication part configured to receive and transmit information, and a traveling part by which the robot itself travels in the indoor space; and a server that comprises a third communication part configured to receive and transmit information and that is configured to detect behavior of a mobile entity in the indoor space, based on detection information which is information detected by the first sensor of each of a plurality of the sensor devices and another detection information which is information detected by the second sensor of the robot,

the interface device also configured to allow a user to enter, on a screen, data on a position at which each of a plurality of the sensor devices is installed in the indoor space.

[Claim 9]

A robot communicably connected to each of a plurality of sensor devices installed in an indoor space, each of a plurality of the sensor devices comprising a first sensor configured to detect information and a first communication part configured to transmit information, the robot comprising:

a second sensor configured to detect information;

a second communication part configured to receive and transmit information;

and

a traveling part by which the robot itself travels in the indoor space,
wherein the robot is communicably connected to

a server that comprises a third communication part configured to receive and transmit information and that is configured to detect a behavior of a mobile entity in the indoor space, based on detection information which is information detected by the first sensor of each of a plurality of the sensor devices and another detection information which is information detected by the second sensor of the robot, and

an interface device configured to allow a user to enter, on a screen, data on a position at which each of a plurality of the sensor devices is installed in the indoor space.