

Description

Title of Invention: MOVING OBJECT AND METHOD FOR USING SAME

5 Technical Field

[0001]

The present invention relates to a moving object and a method for using the same. More specifically, the present invention relates to a moving object configured to move in any environment, for example, in closed-type
10 spaces including a cylindrical space and a rectangular space, and a method for using the same.

Background Art

[0002]

15 Sewer pipes are expected to last about 50 years and thus the number of facilities with sewer pipes reaching the end of the life expectancies is expected to considerably increase in the future. For efficient maintenance, it is essential to check the conditions of sewer pipelines.

[0003]

20 Conventionally, methods for checking the conditions of sewer pipelines include a direct visual check by an inspector in a pipe, image-capturing by a television camera placed in a pipe and connected to the ground via a cable, and image-capturing by a moving television camera mounted on a mobile vehicle in a pipe and connected to the ground via a
25 cable. However, a direct visual check by an inspector may suffer various problems, for example, poisonous gas may be generated in a sewer pipeline and affect a human body or sudden rain may cause a flood. Moreover, in the method using a television camera placed in a pipe, a sufficient inspection speed may not be obtained or a vehicle may be difficult to control when a
30 water level rises in a sewer pipeline.

[0004]

Furthermore, in some thin sewer pipelines, a direct visual check by an inspector and traveling of a mobile vehicle are difficult. Thus, in order to inspect such pipelines, unmanned machines suitably designed for miniaturization are needed.

Citation List

Patent Literature

[0005]

Patent Literature 1: Japanese Patent Laid-Open No. 2017-087917 (Japan)

Patent Literature 2: Japanese Patent Laid-Open No. 2017-226259 (Japan)

Patent Literature 3: Japanese Patent Laid-Open No. 2018-001967 (Japan)

Summary

[0006]

The disclosure provides a moving object suitably configured for miniaturization when viewed in at least one direction, and a method for using the same.

[0007]

In an aspect, the disclosure provides a moving object including at least two rotors arranged back and forth in a traveling direction, and a drive device for driving the at least two rotors and rotating at least two of the at least two rotors in different directions, wherein the moving object further comprises a cover member at least partially covering the at least two rotors with a side surface, with respect to the traveling direction, of the cover member, wherein the cover member has a hollow structure elongated along the traveling direction, the cover member is opened at the forward end and at the back end with respect to the traveling direction, and the cover member is provided with exhaust holes arranged along the traveling direction in the side surface at a lower side of the cover member, each of the exhaust holes diagonally extending through a side wall of the cover member from the inside to the outside of the cover member and diagonally backwardly with respect to the traveling direction.

[0008]

The drive device may include at least two motors for providing the respective rotors with powers, and at least two of the at least two motors may be configured to rotate the rotors powered by them in different

directions.

[0009]

In an example, the disclosure provides the moving object according to the above aspect, comprising an attitude information sensor for measuring attitude information on the attitude of the moving object; and an attitude control unit for controlling the drive device such that the attitude of the moving object is controlled by controlling the rotation speed of at least one of the at least two rotors according to the attitude information measured by the attitude information sensor.

[0010]

The moving object may further include a traveling-direction shooting camera and a traveling-direction captured-image data transmitter. The moving object may be configured to capture an image in the traveling direction by means of the traveling-direction shooting camera and move while transmitting obtained traveling-direction captured-image data from the traveling-direction captured-image data transmitter to the outside.

[0011]

The moving object may further include a rear-direction shooting camera.

[0012]

The moving object may be configured such that the rear-direction shooting camera is positioned on the rear side of the at least two rotors in the traveling direction and at least a part of the rotors is not interrupted by the rear-direction shooting camera when viewed from the rear side.

[0012A] In another aspect, the disclosure provides a method comprising the steps of moving a moving object in a traveling direction in a closed-type space, the moving object including: at least two rotors arranged back and forth in the traveling direction;

a drive device for driving the at least two rotors and rotating at least two of the at least two rotors in different directions; and a rear-direction shooting camera, wherein the moving object is connected to a linear member; and capturing images inside the closed-type space by means of the rear-direction shooting camera while moving the moving object in a direction opposite to the traveling direction by using the linear member, wherein the moving object further comprises a cover member at least partially covering the at least two rotors with a side surface, with respect to the traveling direction, of the cover member, wherein the cover member has a hollow structure elongated along the traveling direction, the cover member is opened at the forward end and at the back end with respect to the traveling direction, and the cover member is provided with exhaust holes arranged along the traveling direction in the side surface at a lower side of the cover member, each of the exhaust holes diagonally extending through a side wall of the cover member from the inside to the outside of the cover member and diagonally backwardly with respect to the traveling direction.

[0013]

The moving object may be connected to a linear member.

[0014]

The linear member may include a power supply line, and the moving object may be configured to move while receiving power supply from an external power supply through the power supply line.

[0015]

The moving object may further include a cover member at least partially covering the at least two rotors with a side surface, with respect to the traveling direction, of the cover member. The cover member may be provided with exhaust holes in the side surface at a lower side of the cover member.

[0016]

The present invention provides a method for using a moving object, the moving object including: at least two rotors arranged back and forth in the traveling direction; a drive device for driving the at least two rotors and rotating at least two of the at least two rotors in different directions; and a rear-direction shooting camera, the method including the steps of: moving the moving object in the traveling direction in a closed-type space, the moving object being connected to linear members; and capturing the interior of the closed-type space by means of the rear-direction shooting camera while moving the moving object in a direction opposite to the traveling direction by using the linear member.

Advantageous Effect of Invention

[0017]

The moving object according to the present invention includes the at least two rotors arranged back and forth in the traveling direction. This configuration is suitable for miniaturization when viewed in the traveling direction. Using the configuration enables operations in various environments.

Brief Description of Drawings

[0018]

[Figure 1A] Figure 1A is a perspective view of a moving object according to an embodiment of the present invention.

[Figure 1B] Figure 1B is a perspective rear view illustrating the moving

object of Figure 1A in the traveling direction.

[Figure 1C] Figure 1C illustrates the moving object of Figure 1A in the negative direction of y.

[Figure 1D] Figure 1D illustrates a cross section of the moving object of Figure 1A, the cross section being taken along A-A plane of Figure 1C.

[Figure 1E] Figure 1E illustrates an example of a gas flow when rotors are rotated in the cross-sectional view of Figure 1D.

[Figure 1F] Figure 1F illustrates a cross section of the moving object of Figure 1A, the cross section being taken along D-D plane of Figure 1D.

[Figure 1G] Figure 1G illustrates a cross section of the moving object of Figure 1A, the cross section being taken along F-F plane of Figure 1D.

[Figure 1H] Figure 1H illustrates the moving object of Figure 1A in the direction of an arrow G of Figure 1D.

[Figure 1I] Figure 1I illustrates the internal structure of the moving object of Figure 1A.

[Figure 1J] Figure 1J illustrates the rotation directions of the rotors without illustrating the body part and the connecting arms of the internal structure of Figure 1I.

[Figure 1K] Figure 1K indicates the rotation direction of the rotor and the rotation direction of torque generated by the rotation of the rotor.

[Figure 2] Figure 2 illustrates the configuration of the moving object provided with two rotors according to the embodiment of the present invention.

[Figure 3] Figure 3 is a block diagram illustrating the functional configuration of the moving object in Figure 1A.

[Figure 4] Figure 4 is an explanatory drawing illustrating wires laid in the hollow parts of a cover member and connecting arms in the moving object of Figure 1A.

[Figure 5] Figure 5 illustrates a configuration in which linear members are connected to the moving object such that the linear members are drawn

through holes on the moving object of Figure 1A.

[Figure 6] Figure 6 schematically illustrates a configuration in which power supply lines are connected from the outside to a power supply system in the body part of the moving object in Figure 1A.

5 [Figure 7] Figure 7 illustrates a configuration in which exhaust holes are provided on the underside of the cover member of the moving object in Figure 1A.

[Figure 8] Figure 8 illustrates gas flows when the rotors rotate in the configuration where the exhaust holes are formed as in Figure 7.

10 [Figure 9] Figure 9 illustrates the structure of a sewer pipeline facility where the moving object of Figure 1A can be moved.

[Figure 10] Figure 10 illustrates the moving object of Figure 1A, the moving object moving in a cylindrical space in the sewer pipeline facility of Figure 9.

[Figure 11] Figure 11 illustrates that the linear members are pulled after a forward movement of the moving object in Figure 10, so that a rear-direction shooting camera captures the interior of a closed-type space while the moving object is moved rearward.

[Figure 12] Figure 12 shows an example of an image in the sewer pipeline to be captured by a front camera.

20

Description of Embodiment

[0019]

A moving object and a method for using the same according to an embodiment of the present invention will be described below with reference to the accompanying drawings. It should be noted that the moving object and the method for using the same according to the present invention are not limited to the following specific embodiment and can be optionally changed within the scope of the present invention. For example, the moving object of the present invention is not necessarily configured as an autonomously controlled moving object. The functional configuration of the moving object

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is not limited to that of Figure 3 and any configuration may be used as long as similar operations can be performed. For example, operations to be performed by a plurality of components may be performed by a single component by integrating the function of a communication unit with a main arithmetic unit or operations to be performed by an illustrated single component may be performed by a plurality of components by distributing the function of the main arithmetic unit to a plurality of arithmetic units. The autonomous control program of the moving object may be recorded in recording devices such as a hard disk drive and read and executed by the main arithmetic unit (an illustrated autonomous control program may be divided into a plurality of program modules or any other programs may be executed by, for example, the main arithmetic unit) or similar operations may be performed by a built-in system using a microcomputer or the like. The moving object of the present invention may not be provided with all the components of the following embodiment (for example, if the moving object is completely moved by external control without autonomous control, an autonomous control program and databases are not necessary). The method of the present invention may not be provided with all the steps of the embodiment. Rotors provided for the moving object (any rotors including a propeller for generating thrust and a rotary wing for floating the moving object may be used. In the following example, a rotor including three rotor blades is used and the rotor may have any specific structure) are not limited to three rotors 5 to 7 that are illustrated in, for example, Figure 1J. Any two or more rotors may be used instead. The rotor may have any shapes such as a twisted shape. The moving object may have any size. In the following example, the moving object moves while taking photographs in a closed-type space. The moving object of the present invention can be moved for any purpose in any environment instead of the closed-type space ("moving" of the moving object may be moving in any form, for example, moving in sliding contact with the ground or a water surface, moving in a

noncontact manner in the configuration of Figure 8, or floated and flown by the rotations of the rotors). The closed-type space is not limited to a completely closed-type space. At least a part of the space may be closed so as to restrict at least part of the moving of the moving object. For example,
5 as will be described in the following embodiment, a cylindrical space in a sewer pipeline connected to the outside via a manhole is also a closed-type space and a highway tunnel is also a closed-type space. Members constituting the moving object may be made of, for example, metals or plastics. The members may be made of any materials such as an elastic
10 body if the functions of the moving object are obtained.

[0020]

The configuration of the moving object

Figures 1A to 1J illustrate the appearance, internal configuration, and cross-sectional views of the three-rotor moving object according to the
15 embodiment of the present invention. Figure 1A is a perspective view, Figure 1B is a perspective rear view illustrating the moving object of Figure 1A in a traveling direction, Figure 1C is a view in the negative direction of y, and Figure 1D illustrates a cross section taken along A-A plane of Figure 1C (The interior of a body part 3 is omitted. Also in other drawings, some
20 components are omitted to simplify the explanation). Figure 1E illustrates an example of a gas flow when the rotors are rotated, Figure 1F illustrates a cross section of the moving object of Figure 1A, the cross section being taken along D-D plane of Figure 1D, Figure 1G illustrates a cross section of the moving object of Figure 1A, the cross section being taken along F-F plane of
25 Figure 1D, Figure 1H illustrates the moving object of Figure 1A in the direction of an arrow G of Figure 1D, Figure 1I illustrates the internal structure of the moving object of Figure 1A, and Figure 1J illustrates the rotation directions of the rotors without illustrating the body part and the connecting arms of the internal structure of Figure 1I. As illustrated in
30 Figure 1A, a rotation in the direction of an arrow about the x-axis direction of

Figure 1A is (positive) rolling, a rotation in the direction of an arrow about y axis is (positive) pitching, and a rotation in the direction of an arrow about z axis is (positive) yawing (in Figure 1B and subsequent drawings, the coordinate axes are shifted from a moving object 1 for ease of viewing).

5 [0021]

For example, the moving object 1 is designed with a total width of about 160 mm (in y direction in Figure 1A) and an overall length of about 500 mm (in x direction in Figure 1A) so as to move in a closed-type space having a diameter of about 400 mm. The moving object 1 includes the body
10 part 3 (stored in a waterproof case 4), three motors 8 to 10 (see Figure 3) for driving under the control of the body part 3, the three rotors 5 to 7 that are rotated by the driving of the motors 8 to 10 and move the moving object 1 (at least two of the rotors 5 to 7 rotate in different directions such that, for example, the rotors 5 and 7 rotate counterclockwise when viewed from the
15 negative-direction side of x while the rotor 6 rotates clockwise when viewed from the negative-direction side of x. The rotation axes of the rotors 5 to 7 extend along x axis of Figure 1A (also along the traveling direction) and the rotors 5 to 7 rotate along planes orthogonal to x axis of Figure 1A (as has been discussed, this configuration is not always necessary and thus the
20 rotation axes of the rotors 5 to 7 and planes and spaces where the rotors 5 to 7 rotate are basically optional). See Figure 1J. The rotor 5 includes rotor blades 5a, 5b, and 5c, the rotor 6 includes rotor blades 6a, 6b, and 6c, and the rotor 7 includes rotor blades 7a, 7b, and 7c. See Figures 1F and 1H), a front camera 14, and a rear-direction shooting camera 15. The components
25 including the rotors and the body part are at least partially covered with a cover member 2 on the side of the moving object 1 in the traveling direction (the positive direction of x in Figure 1A). The cover member 2 is similar in shape to the side of a cylinder (a hollow shape as will be described later). The cover member 2 has holes 46 to 48 for connection to the moving object 1
30 via linear members 49 to 51 as will be describe later (see Figure 5). The

rotors 5 to 7 are arranged back and forth in the traveling direction, allowing size reduction when viewed in the traveling direction (in Figure 1A, the size of the area of the moving object 1 on yz plane). Regarding this point, the configuration of the moving object 1 is advantageous for moving through thin
5 pipes or the like.

[0022]

The front camera 14 is a camera for capturing still images or moving images in the traveling direction when being moved in a closed-type space by the moving object 1. Data on the captured still images or moving images is
10 transmitted to an external apparatus (e.g., a computer provided with a display) at any time. An operator can operate the moving object 1 while checking the data. The rear-direction shooting camera 15 is a camera for capturing still images or moving images rearward (in Figure 1A, the negative direction of x) when being moved in a closed-type space by the
15 moving object 1. A commercial camera of, for example, GoPro session (TAJIMA MOTOR CORPORATION Co., Ltd.) may be used. The front camera 14 and the rear-direction shooting camera 15 may be cameras such as an infrared camera and an ultraviolet camera.

[0023]

As illustrated in Figure 1D, the motors 8 to 10 are held by motor holding parts 11 to 13, respectively (the motor holding part 11 also holds the front camera 14 and the rear-direction shooting camera 15 is connected to the body part 3 and is held by the waterproof case 4). The motor holding part 11 is connected to the cover member 2 via connecting arms 16 to 18, the
25 motor holding part 12 is connected to the cover member 2 via connecting arms 19 to 21, and the motor holding part 13 is connected to the cover member 2 via connecting arms 22 to 24 (Figure 1I). The waterproof case 4 accommodating the body part 3 is connected to the cover member 2 via connecting arms 25 to 30 (Figure 1I). As will be described later with
30 reference to Figure 4, the connecting arms 16 to 30, the cover member 2, and

the waterproof case 4 are formed as hollow members. Wires or the like are passed through the hollow parts so as connect the components included in the body part 3 to components such as the front camera 14 and the motors 8 to 10 outside the body part 3.

5 [0024]

When the rotors 5 to 7 rotate, for example, gas flows in directions indicated by arrows W in Figure 1E (when the traveling direction is a horizontal direction, that is, a direction orthogonal to gravity), allowing the moving object 1 to move in the traveling direction (x direction in Figure 1A).

10 In the moving object 1 of the present example, the rear-direction shooting camera 15 is positioned on the rear side of the rotors 5 to 7 in the traveling direction (in Figure 1A, on the negative-direction side of x). As illustrated in Figure 1H, the rotors 5 to 7 are disposed such that at least a part of the rotors 5 to 7 is not interrupted by the rear-direction shooting camera 15
15 when viewed from the rear side (the rotor blades 5a, 5b, and 5c of the rotor 5 are omitted in Figure 1H but are disposed such that at least a part of the rotor blades is not interrupted by the rear-direction shooting camera 15 like the rotors 6 and 7). This generates gas flows as illustrated in Figure 1E. However, the layout of the rotors 5 to 7 is not always necessary. Even if the
20 rotors 5 to 7 are completely interrupted by the rear-direction shooting camera 15 when viewed from the rear side, openings (clearances) may be obtained so as to deliver gas from the positions of the rotors 5 to 7 to the rear side as indicated by the arrows W in Figure 1E. In an example, thrust is generated by a reaction of gas and moves the moving object 1. In another
25 example, lift is generated by the rotations of the rotors 5 to 7 and floats the moving object 1 (when the traveling direction is a vertically upward direction, that is, a direction opposite to the direction of gravitational force). In the following explanation, the traveling direction of the moving object 1 is basically a horizontal direction. It is to be noted that the traveling direction
30 may be defined as any direction.

[0025]

Figure 1K indicates the rotation direction of the rotor and the rotation direction of torque generated by the rotation of the rotor. In Figure 1K, the rotation of the rotor 5 (6, 7) in the direction of an arrow R generates, as a reaction of the rotation, torque for rotating the moving object 1 in the direction of an arrow T in Figure 1K. In the present example, at least two of the rotors 5 to 7 rotate in different directions. If the rotors 5 to 7 are rotated in directions indicated in Figure 1J, torque generated by the rotations of the rotors 5 and 7 and torque generated by the rotation of the rotor 6 rotate the moving object 1 in opposite directions. Thus, the rotations (rolling) of the moving object 1 by the actions of the torque generated by the rotations of the rotors can be cause to at least partially cancel each other out and produce a lower torque.

[0026]

As described above, the number of rotors is not limited to three and may be any number not smaller than two. Figure 2 illustrates an example of the configuration of the moving object provided with two rotors. The configuration of the moving object 1 in Figure 2 may be identical to that of the three-rotor moving object 1 except for the provision of the two rotors. In the moving object 1 of Figure 2, the rotors 5 and 7 are rotated in different directions. For example, the rotor 5 is rotated counterclockwise when viewed in the negative direction of x in Figure 1A and the rotor 7 is rotated clockwise when viewed in the negative direction of x in Figure 1A. Thus, at least the rotations of the moving object 1 can be reduced like the three-rotor moving object 1.

[0027]

Figure 3 is a block diagram illustrating the functional configuration of the moving object in Figure 1A. The body part 3 of the moving object 1 includes: a main arithmetic unit 31a that includes a processor and a temporary memory and performs various operations; a signal conversion

unit 31b that performs processing such as the conversion of control-command-value data obtained by the operations of the main arithmetic unit 31a into a pulse signal (PWM: Pulse Width Modulation signal) and includes a processor and a temporary memory (an arithmetic
5 unit including the main arithmetic unit 31a and the signal conversion unit 31b will be referred to as a control-signal generation unit 32), speed controllers (ESC: Electric Speed Controller) 33 to 35 that convert a pulse signal generated by the control-signal generation unit 32 into a driving current to the motors 8 to 10; a communication antenna 36 and a
10 communication unit 37 (including a processor and a temporary memory) that transmit and receive data signals to and from the outside; a sensor unit 38 including sensors such as a GPS (Global Positioning System) sensor, an attitude information sensor, an altitude sensor, and an orientation sensor; a recorder 40 including recording devices such as hard disk drives for
15 recording an autonomous control program 39a and databases 39b; and a power supply system 41 including battery devices for a lithium polymer battery and a lithium ion battery and a distribution system for the elements. Additionally, the moving object 1 may include any functional units and information according to the use of the function.

20 [0028]

The attitude information sensor included in the sensor unit 38 may be, for example, a three-axis angular velocity sensor for measuring the angular velocities of the rotations of rolling, pitching, and yawing in the moving object 1 in Figure 1A. The sensor may be installed as a "six-axis
25 gyro" sensor in the moving object 1, the gyro sensor being combined with acceleration sensors for measuring accelerations in x direction, y direction, and z direction of Figure 1A. In this case, "attitude information" may be information including at least one of the angular velocities of the rotations of rolling, pitching, and yawing or information including at least one of the
30 rotation angles of a rolling angle, a pitching angle, and a yawing angle as

information on the inclination of the moving object 1, the inclination being obtained by integrating the measurement value of the angular velocity measured by the angular velocity sensor with respect to time (an integration calculation may be performed by, for example, any arithmetic unit provided
5 in the attitude information sensor or the main arithmetic unit 31a). In this case, "measurement" is not limited to the measurement of an angular velocity and may include the determination of, for example, the rotation angle from the measurement value of a measured angular velocity or the like by calculation. For example, in a configuration where an angular velocity is
10 measured by the angular velocity sensor and a rotation angle is calculated by the main arithmetic unit 31a, the angular velocity sensor and the main arithmetic unit 31a may constitute "attitude information sensor." The main arithmetic unit 31a executes the autonomous control program 39a by using the attitude information, so that a control command value for controlling the
15 rotation speed of at least one of the rotors 5 to 7 is calculated. The signal conversion unit 31b converts control-command-value data obtained by the operation of the main arithmetic unit 31a into a pulse signal, the speed controllers 33 to 35 convert the pulse signal into a driving current to the motors 8 to 10, and the motors 8 to 10 control the rotation speeds of the
20 rotors 5 to 7, enabling attitude autonomous control (in this case, the control-signal generation unit 32 including the main arithmetic unit 31a and the signal conversion unit 31b acts as an attitude control unit and controls the motors 8 to 10 via the speed controllers 33 to 35). As a specific example, for example, if a measurement using the attitude sensor detects that the
25 body of the moving object 1 (in the present example, components other than the rotors 5 to 7 constitute the body in the moving object 1) has an angular velocity for positive rolling (a rotation in the direction of an arrow about x axis in Figure 1A) or the body has been already inclined by positive rolling, the main arithmetic unit 31a can determine a control command value for
30 increasing the rotation speed of the rotor 6 and reducing the rotation speeds

of the rotors 5 and 7 (in other words, torque for rotating the moving object 1 opposite to the rotation direction of the moving object 1 can be generated or increased by relatively increasing the rotation speed of the rotor that rotates in the same direction as the rotation speed of the moving object 1) in order to
5 generate torque for negative rolling of the moving object 1 (on the assumption that the rotors 5 to 7 rotate in the directions of Figure 1J). As described above, the rotation speeds of the rotors 5 to 7 are controlled by using the control command value, thereby reducing at least the positive or negative rolling of the body of the moving object 1 so as to obtain a stable
10 attitude. In an example of an operation in a semiautomatic mode in the moving object 1, an external control signal for accelerating or decelerating the moving object 1 in the forward direction is transmitted from an external controller (not illustrated), the moving object 1 receives the external control signal via the communication antenna 36, the communication unit 37
15 performs necessary processing such as filtering and conversion and then transmits the signal to the main arithmetic unit 31a, and the main arithmetic unit 31a generates the control command value for increasing or reducing the rotation speeds of the rotors 5 to 7 in response to the external control signal. Thereafter, as has been discussed, the moving speed of the
20 moving object 1 is controlled by a process for controlling the rotation speeds of the rotors 5 to 7 by processing such as conversion on a pulse signal; meanwhile, as described above, the attitude of the moving object 1 is autonomously controlled by the attitude information sensor and the attitude control unit. In the autonomous control of the attitude, the rotation speeds
25 of some of the rotors may be increased and the rotation speeds of the other rotors may be reduced so as to keep constant the total of the rotation speeds of the rotors or adjust the total of the rotation speeds to any rotation speed. Alternatively, the attitude may be controlled only by increasing or reducing the rotation speeds of some of the rotors. In an example of a manual mode
30 in the moving object 1, external control signals for separately increasing or

reducing the rotation speed of the rotor 5, the rotation speed of the rotor 6, and the rotation speed of the rotor 7 can be transmitted from the external controller and the moving object 1 can separately control the rotation speeds of the rotors 5 to 7 in response to the external control signals. In this case, the attitude of the moving object 1 is manually controlled as well as the moving speed.

[0029]

Figure 4 is an explanatory drawing illustrating wires laid in the hollow parts of the cover member and the connecting arms in the moving object of Figure 1A. As described above, the connecting arms 16 to 30, the cover member 2, and the waterproof case 4 are formed as hollow members. As illustrated in Figure 4, the hollow parts of the members are connected so as to lay the wires between the members (In Figure 4, the hollow parts and the connected parts are illustrated in the same plane for convenience but as illustrated in Figure 1 I, it is to be noted that all the connecting arms 16 to 30 are not always disposed in the same plane. Also in, for example, Figure 6.) In the configuration of Figure 4, the speed controller 33 and the motor 8 are connected to each other via wires (conductors) 42 laid through the hollow part of the waterproof case 4, the hollow part of the connecting arm 28, the hollow part of the cover member 2, and the hollow part of the connecting arm 16 (in Figure 4, the wires 42 are connected to the motor holding part 11 but the wires 42 are actually connected to the motor 8. The speed controllers 34 and 35 and the motors 9 and 10 are similarly connected via wires (conductors) 43 and 44.). The speed controller 34 and the motor 9 are connected to each other via the wires (conductors) 43 laid through the hollow part of the waterproof case 4, the hollow part of the connecting arm 27, the hollow part of the cover member 2, and the hollow part of the connecting arm 21. The speed controller 35 and the motor 10 are connected to each other via the wires (conductors) 44 laid through the hollow part of the waterproof case 4, the hollow part of the connecting arm 27, the hollow part of the cover

member 2, and the hollow part of the connecting arm 24. Moreover, the main arithmetic unit 31a and the front camera 14 are connected to each other via wires (signal lines) 45 laid through the hollow part of the waterproof case 4, the hollow part of the connecting arm 28, the hollow part
5 of the cover member 2, and the hollow part of the connecting arm 16.

[0030]

Figure 5 illustrates a configuration in which the linear members are connected to the moving object such that the linear members are drawn through the holes on the moving object of Figure 1A. The linear members
10 49 to 51 such as strings are drawn through the holes 46 to 48 on the cover member 2, so that the linear members 49 to 51 are connected to the moving object 1. As will be described later with reference to Figure 11, the linear members 49 to 51 are pulled after a forward movement of the moving object 1, so that the rear-direction shooting camera 15 can capture the interior of the
15 closed-type space while the moving object 1 is moved rearward.

[0031]

The linear members 49 to 51 such as strings may be replaced with any linear members. As an example, Figure 6 schematically illustrates a configuration in which power supply lines 52 are connected from the outside
20 to the power supply system 41 in the body part 3 of the moving object 1 in Figure 1A. In the configuration of Figure 6, the power components including the motors 8 to 10 in the moving object 1 are operated by power supplied from an external power supply (not illustrated) through the power supply lines 52. The power supply lines 52 are connected to, for example, a
25 circuit (not illustrated) for power distribution control in the power supply system 41 (via the hollow part in the cover member 2). Specifically, power is supplied to the power supply system 41 through the power supply lines 52, power is supplied to the components including the main arithmetic unit 31a and the speed controllers 33 to 35 through the circuit for power distribution
30 control in the power supply system 41, and as described above, current is

supplied to the motors 8 to 10 from the speed controllers 33 to 35 so as to rotate the rotors 5 to 7. Like the configuration in which the linear members 49 to 51 are used, the power supply lines 52 are pulled after a forward movement of the moving object 1, so that the rear-direction shooting camera 15 can capture the interior of the closed-type space while the moving object 1 is moved rearward.

[0032]

Moreover, a gas flow during a movement of the moving object can be regulated by providing exhaust holes (Figure 7) on one side of the underside of the cover member (in Figure 1A, the positive-direction side of z). In the configuration of Figure 7, exhaust holes 53 to 57 that are rectangular in cross section are provided (as illustrated in Figure 8(b), the exhaust holes diagonally extend through the side wall of the cover member 2 when viewed from a cross section of the cover member 2.). Figure 8 illustrates gas flows when the rotors rotate in the configuration of Figure 7 (a two-rotor type is illustrated for simplicity and the gas flows of a three-rotor type are similar to those of the two-rotor type. The moving object 1 moves in a sewer pipe 58 that is illustrated as an example of the closed-type space.). Gas flows between the moving object 1 and the lower boundary surface of a closed-type space or the like (the boundary surface may be the inner surface of a sewer pipe or an interface with water or the like in the sewer pipe.), thereby generating flows of gas as indicated by arrows W2 in Figure 8 unlike the gas flows indicated by the arrows W in Figure 1E. The flowing gas is expected to float the moving object 1 or reduce at least friction between the cover member 2 of the moving object 1 and the lower boundary surface.

[0033]

Moving and photographing by the moving object in a closed-type space

Referring to Figures 9 to 12, moving and photographing in a sewer pipeline will be described below as an example of moving and photographing by the moving object 1 in a closed-type space. However, as described above,

the use of the moving object and the method for using the same according to the present invention is not limited to the moving and photographing. The moving object and the method for using the same according to the present invention are usable for any purpose in any environment.

5 [0034]

Figure 9 illustrates the structure of a sewer-pipe-line facility where the moving object of Figure 1A can be moved. A manhole 60a provided on a ground surface 59 communicates with a sewer pipeline 61 and moving in the sewer pipeline 61 to the right in Figure 9 reaches another manhole 60b (In
10 Figure 9, the sewer pipeline 61 cut at two points is illustrated for convenience but the actual sewer pipeline 61 is seamlessly formed and is extended longer than that of Figure 9.). The boundary surface of the closed-type space is determined by an inner wall 62 of the sewer pipeline 61. The sewer pipeline 61 further includes connecting points 63 placed at
15 predetermined distances to the right in Figure 9.

[0035]

In moving and photographing by the moving object 1 in the sewer pipeline 61, the moving object 1 is first placed into the manhole 60a and then is lowered to the depth of the sewer pipeline 61. For example, a holding
20 base is provided at the tip of a pole as long as the depth of the manholes 60a and 60b. The pole is inserted into the manhole 60a with the moving object 1 placed on the holding base, so that the moving object 1 is lowered.

[0036]

The moving object 1 connected to the linear members 49 to 51 or the
25 power supply lines 52 (see Figure 6) starts moving and photographing (Figure 10) from the starting position of moving and photographing to the right in Figure 9 (the direction is the positive direction of x, that is, the traveling direction in Figure 1A). In this case, the moving object 1 operates according to the example of the semiautomatic mode. The moving object 1
30 autonomously controls the attitude while moving in the traveling direction in

response to an external control signal from the external controller that provides an instruction for acceleration or deceleration in the forward direction, and the moving object 1 captures still images or moving images in the sewer pipeline 61 by means of the front camera 14 and the rear-direction shooting camera 15. The sewer pipeline 61 normally contains water 64. The moving object 1 may move in the traveling direction while being placed in contact with the water surface of the water 64 or at least partially immersed in the water 64. Alternatively, the moving object 1 may move in the traveling direction in contact with the lower wall surface of the sewer pipe. In the absence of the water 64, for example, the moving object 1 in contact with the lower wall surface of the sewer pipe moves in the traveling direction. As has been discussed with reference to Figures 7 and 8, the moving object 1 may be floated and moved by regulating a gas flow between gas and the lower wall surface of the sewer pipe through, for example, the exhaust holes 53 to 57 provided on the underside of the cover member 2 (the moving object 1 can be similarly floated in the presence of the water 64 or the like).

[0037]

Data on still images or moving images captured by the rear-direction shooting camera 15 is recorded in the internal memory of the rear-direction shooting camera 15 and data on still images or moving images captured by the front camera 14 is recorded in the internal memory of the front camera 14 and is transmitted at any time to the external computer of an operator from the communication antenna 36 by the communication unit 37. The operator displays the still images or moving images captured by the front camera 14 on the display of the external computer by using the received data and operates the moving object 1 through the external controller while checking the images (in the case of insufficient communication quality between the external controller and the communication antenna 36, a radio relay station is preferably installed in advance in the sewer pipeline 61. A

GPS signal can be similarly received via a radio relay station or the like.). For example, the operator operates the moving object 1 while checking a traveling distance of the moving object 1 by using the connecting points 63 as markers in the displayed still images or moving images.

5 [0038]

When the moving object 1 reaches the other end of the sewer pipeline 61 (in Figure 9, the right end of the sewer pipeline 61. Hereinafter, the right end will be referred to as an end position G of moving and photographing.) or the moving object 1 cannot move forward any more because of the lengths of the linear members 49 to 51 (or the power supply lines 52), the forward movement of the moving object is completed (the forward movement may be completed at any time under the control of the external controller). The transmission of the external control signal from the external controller is stopped (or a stop signal is transmitted) to stop the rotations of the rotors 5 to 7 of the moving object 1, and then the sewer pipeline 61 is captured by the rear-direction shooting camera 15 while the moving object 1 is moved rearward (the negative direction of x in Figure 1A) by pulling the linear members 49 to 51 (or the power supply lines 52) connected to the moving object 1. This enables photographing without being affected by, for example, water splashes caused by the rotations of the rotors 5 to 7. Alternatively, photographing by the rear-direction shooting camera 15 may be performed only when the moving object 1 moves rearward described above. In this case, photographing by the rear-direction shooting camera 15 may be stopped during a forward movement of the moving object 1, the rotations of the rotors 5 to 7 are stopped after the completion of the forward movement, and then photographing by the rear-direction shooting camera 15 may be started in response to a control signal or the like from a remote controller.

[0039]

30 The moving object 1 is returned to the starting position S (Figure 9)

by continuously pulling the linear members 49 to 51 (or the power supply lines 52). The pole with the holding base at the tip of the pole is inserted into the manhole 60a, the moving object 1 is placed on the holding base, and then the pole is lifted, so that the moving object 1 is collected. The rear-direction shooting camera 15 is removed from the collected moving object 1 and the conditions of, for example, the sewer pipeline 61 and the inner wall 62 can be checked by viewing still images or moving images recorded in the memory of the camera.

[0040]

Figure 12 shows an example of an image in the sewer pipeline to be captured by the front camera. A similar image is expected to be captured by the moving and photographing of the moving object 1 including the front camera 14. An operator can operate the moving object 1 by using the external controller while viewing still images or moving images captured from a first-person viewpoint by the front camera 14 of Figure 12. After the moving and photographing, the rear-direction shooting camera 15 is removed from the collected moving object 1 and the conditions of the sewer pipeline 61, for example, cracks on the inner wall 62 or displaced gaskets at the connecting points 63 can be checked by viewing still images or moving images recorded in the memory of the camera.

Industrial Applicability

[0041]

The present invention can be used for photographing and inspections in any closed-type spaces such as a water-supply pipeline, a sewer pipeline, a drain, a highway tunnel, a highway drain, a cable tunnel, a duct, a pipe shaft, and a gas pipeline. The present invention can be also used when the moving object is moved for any purpose in any spaces other than a closed-type space.

Reference Signs List

[0042]

	1	Moving object
	2	Cover member
5	3	Body part
	4	Waterproof case
	5 to 7	Rotor
	5a to 7c	Rotor blade
	8 to 10	Motor
10	11 to 13	Motor holding part
	14	Front camera
	15	Rear camera
	16 to 30	Connecting arm
	31a	Main arithmetic unit
15	31b	Signal conversion unit
	32	Control-signal generation unit
	33 to 35	Speed controller
	36	Communication antenna
	37	Communication unit
20	38	Sensors
	39a	Autonomous control program
	39b	Databases
	40	Recorder
	41	Power supply system
25	42 to 45	Wire
	46 to 48	Hole
	49 to 51	Linear member
	52	Power supply line
	53 to 57	Exhaust holes
30	58	Sewer pipe

	59	Ground surface
	60a, 60b	Manhole
	61	Sewer pipeline
	62	Inner wall
5	63	Connecting point
	64	Water

Claims

[Claim 1]

A moving object comprising:

5 at least two rotors arranged back and forth in a traveling direction;
and

 a drive device for driving the at least two rotors and rotating at least
two of the at least two rotors in different directions,

 wherein the moving object further comprises a cover member at least
10 partially covering the at least two rotors with a side surface, with respect to
the traveling direction, of the cover member, wherein the cover member has
a hollow structure elongated along the traveling direction, the cover member
is opened at the forward end and at the back end with respect to the
traveling direction, and the cover member is provided with exhaust holes
15 arranged along the traveling direction in the side surface at a lower side of
the cover member, each of the exhaust holes diagonally extending through a
side wall of the cover member from the inside to the outside of the cover
member and diagonally backwardly with respect to the traveling direction.

20 [Claim 2]

 The moving object according to claim 1, wherein the drive device
includes at least two motors for providing the respective rotors with powers,
and

 at least two of the at least two motors are configured to rotate the
25 rotors powered by them in different directions.

[Claim 3]

 The moving object according to any one of claims 1 and 2, further
comprising:

30

an attitude information sensor for measuring attitude information on an attitude of the moving object; and

an attitude control unit for controlling the drive device such that the attitude of the moving object is controlled by controlling a rotation speed of
5 at least one of the at least two rotors according to the attitude information measured by the attitude information sensor.

[Claim 4]

The moving object according to any one of claims 1 to 3, further
10 comprising a traveling-direction shooting camera and a traveling-direction captured-image data transmitter,

wherein the moving object is configured to capture an image in the traveling direction by means of the traveling-direction shooting camera and move while transmitting obtained traveling-direction captured-image data
15 from the traveling-direction captured-image data transmitter to outside.

[Claim 5]

The moving object according to any one of claims 1 to 4, further comprising a rear-direction shooting camera.

20

[Claim 6]

The moving object according to claim 5, wherein the rear-direction shooting camera is positioned on a rear side of the at least two rotors in the traveling direction and at least a part of the rotors is not interrupted by the
25 rear-direction shooting camera when viewed from the rear side.

[Claim 7]

The moving object according to any one of claims 1 to 6, wherein the moving object is connected to a linear member.

30

[Claim 8]

The moving object according to claim 7, wherein the linear member includes a power supply line, and

the moving object is configured to move while receiving power supply
5 from an external power supply through the power supply line.

[Claim 9]

A method comprising the steps of:

10 moving a moving object in a traveling direction in a closed-type space,
the moving object including:

at least two rotors arranged back and forth in the traveling
direction;

a drive device for driving the at least two rotors and rotating
15 at least two of the at least two rotors in different directions; and

a rear-direction shooting camera, wherein the moving object
is connected to a linear member; and

capturing images inside the closed-type space by means of the
rear-direction shooting camera while moving the moving object in a direction
20 opposite to the traveling direction by using the linear member,
wherein the moving object further comprises a cover member at least
partially covering the at least two rotors with a side surface, with respect to
the traveling direction, of the cover member, wherein the cover member has
a hollow structure elongated along the traveling direction, the cover member
25 is opened at the forward end and at the back end with respect to the
traveling direction, and the cover member is provided with exhaust holes
arranged along the traveling direction in the side surface at a lower side of
the cover member, each of the exhaust holes diagonally extending through a
side wall of the cover member from the inside to the outside of the cover
30 member and diagonally backwardly with respect to the traveling direction.