as a risk of influence on a human body via generation of poisonous gas inside the sewerage pipe line and a risk by inundation when a rainfall rapidly occurs. And, also in the method of positioning a television camera inside the pipe, there are problems such as an sufficient inspection speed being not obtained, and difficulty in controlling the car when the water level inside the sewerage pipe line rises.

[Summary]

[0004]

Therefore, the present disclosure aims to provide a method, which does not require direct visual observation by an investigator and which has good efficiency, of taking images inside a closed-type space (or a confined space) such as a culvert (a waterway provided underground).

[0005]

In order to solve the above problem (achieve the above aim), the present disclosure provides an unmanned aerial vehicle having at least four rotary wings (rotors), a drive device that drives the rotary wings, a control signal generation circuit that generates a control signal for causing the drive device to drive the rotary wings, and an imaging camera, wherein the unmanned aerial vehicle is configured to fly inside a closed-type space (confined space) with driving the rotary wings while taking (capturing) images inside the closed-type space by means of the imaging camera.

[0005a]

In a first aspect, the present disclosure provides an unmanned aerial vehicle comprising: a frame having a shape elongated along the forward direction; four rotary wings consisting of a first pair of rotary wings and a second pair of rotary wings, wherein the first pair of rotary wings is a pair of

two rotary wings positioned on the front-half side of the frame and the second pair of rotary wings is a pair of two rotary wings positioned on the back-half side of the frame, and wherein the four rotary wings are positioned inside the frame; a drive device that drives the four rotary wings; a control signal generation circuit that generates a control signal for causing the drive device to drive the four rotary wings, wherein the control signal generation circuit is stored in a waterproof case and the waterproof case is positioned between the first pair of rotary wings and the second pair of rotary wings; and an imaging camera, wherein the unmanned aerial vehicle is configured to fly inside a tubular closed-type space extending in a direction other than a vertical direction with driving the four rotary wings while taking images inside the closed-type space by means of the imaging camera, wherein the four rotary wings, the drive device, the waterproof case, and the imaging camera are integrated using the frame, wherein an upper surface of the frame defines four apertures that correspond respectively with one of the four rotary wings, and each of the four apertures is partly covered by the frame.

[0006]

It is possible to further provide the above unmanned aerial vehicle with a member for preceding impact (collision) which is for causing an impact on a boundary surface in advance when the unmanned aerial vehicle impacts on (collides with) the boundary surface of the closed-type space.

so that it further includes a direction of travel imaging camera and a direction of travel imaging data transmitter, and that the unmanned aerial vehicle flies inside the closed-type space while taking images of the direction of travel inside the closed-type space by means of the direction of travel imaging camera and while transmitting, to the outside, the obtained direction of travel imaging data from the direction of travel imaging data transmitter.

[0012]

In addition, the present disclosure provides a method of causing a unmanned aerial vehicle having at least four rotary wings (rotors), a drive device that drives the rotary wings, a control signal generation circuit that generates a control signal for causing the drive device to drive the rotary wings, and an imaging camera, to fly inside a closed-type space (confined space) with driving the rotary wings while taking (capturing) images inside the closed-type space by means of the imaging camera.

[0012a]

In a second aspect, the present disclosure provides a method of causing an unmanned aerial vehicle having: a frame having a shape elongated along the forward directions; four rotary wings consisting of a first pair of rotary wings and a second pair of rotary wings, wherein the first pair of rotary wings is a pair of two rotary wings positioned on the front-half side of the frame and the second pair of rotary wings is a pair of two rotary wings positioned on the back-half side of the frame, and wherein the four rotary wings are positioned inside the frame, a drive device that drives the four rotary wings, a control signal generation circuit that generates a control signal for causing the drive device to drive the four rotary wings, wherein the control signal generation circuit is stored in a waterproof case and the waterproof case is positioned between the first pair of rotary wings and the second pair of rotary wings; and an imaging camera, wherein the four rotary wings, the drive device, the waterproof case, and the imaging camera are

integrated using the frame, wherein an upper surface of the frame defines four apertures that correspond respectively with one of the four rotary wings, and each of the four apertures is partly covered by the; to fly inside a tubular closed-type space extending in a direction other than a vertical direction with driving the four rotary wings while taking images inside the tubular closed-type space by means of the imaging camera.

[0013]

By the present disclosure, taking of images inside the closed-type space with higher safety and without necessity of going underground by an investigator, becomes possible. In addition, in comparison to a self-propelled car, the unmanned aerial vehicle does not tend to impair its mobility even in a case where there is water inside the closed-type space, thus more efficient imaging becomes possible.

[Brief Description of Drawings]

[0014]

[Figure 1A] A perspective view (oblique drawing) of an unmanned aerial vehicle as one embodiment of the present invention

[Figure 1B] A figure showing the unmanned aerial vehicle of Figure 1A

[Document Name] Claims

[Claim 1]

An unmanned aerial vehicle comprising:

a frame having a shape elongated along the forward direction;

four rotary wings consisting of a first pair of rotary wings and a second pair of rotary wings, wherein the first pair of rotary wings is a pair of two rotary wings positioned on the front-half side of the frame and the second pair of rotary wings is a pair of two rotary wings positioned on the back-half side of the frame, and wherein the four rotary wings are positioned inside the frame;

a drive device that drives the four rotary wings;

a control signal generation circuit that generates a control signal for causing the drive device to drive the four rotary wings, wherein the control signal generation circuit is stored in a waterproof case and the waterproof case is positioned between the first pair of rotary wings and the second pair of rotary wings;

and

an imaging camera,

wherein the unmanned aerial vehicle is configured to fly inside a tubular closed-type space extending in a direction other than a vertical direction with driving the four rotary wings while taking images inside the tubular closed-type space by means of the imaging camera,

wherein the four rotary wings, the drive device, the waterproof case, and the imaging camera are integrated using the frame,

wherein an upper surface of the frame defines four apertures that correspond respectively with one of the four rotary wings, and each of the four apertures is partly covered by the frame.

[Claim 2]

The unmanned aerial vehicle according to claim 1, further

comprising a member for preceding impact which is for causing an impact on a boundary surface in advance when the unmanned aerial vehicle impacts on the boundary surface of the tubular closed-type space.

[Claim 3]

The unmanned aerial vehicle according to claim 2, wherein the member for preceding impact is positioned at the side of one edge of the unmanned aerial vehicle and,

when the unmanned aerial vehicle impacts on the boundary surface while flying inside the tubular closed-type space with the side of the one edge as the forward side, the member for preceding impact is configured to impact on the boundary surface on the forward side ahead of the position of the center of gravity of the unmanned aerial vehicle.

[Claim 4]

The unmanned aerial vehicle according to any of claims 1 to 3,

wherein the control signal includes an attitude control signal,

and the unmanned aerial vehicle is configured so that the attitude control signal causes the drive device to drive the rotary wings, and, when the unmanned aerial vehicle is tilted, the attitude of the unmanned aerial vehicle is controlled by reducing the number of rotations of one or some of the rotary wings.

[Claim 5]

The unmanned aerial vehicle according to any of claims 1-4,

wherein the drive device includes four motors which provide the respective rotary wings with motive powers, respectively, and

each of the motors are configured to provide the rotary wing with motive power at a position with a higher gravitational potential than the rotary wing which receives motive power from the each motor.

[Claim 6]

The unmanned aerial vehicle according to any of claims 1 to 5, further comprising a thrust generation propeller inside the frame, and

wherein the unmanned aerial vehicle is configured to propel by rotations of the thrust generation propeller while floating by rotations of the four rotary wings.

[Claim 7]

The unmanned aerial vehicle according to any of claims 1 to 6, further comprising a direction of travel imaging camera and a direction of travel imaging data transmitter,

wherein the unmanned aerial vehicle is configured to fly inside the tubular closed-type space while taking images of the direction of travel inside the tubular closed-type space by means of the direction of travel imaging camera and while transmitting, to the outside, the obtained direction of travel imaging data from the direction of travel imaging data transmitter.

[Claim 8]

The unmanned aerial vehicle according to any of claims 1 to 7, wherein the tubular closed-type space is a tubular space in a sewerage pipeline.

[Claim 9]

A method of causing an unmanned aerial vehicle having:

a frame having a shape elongated along the forward direction;

four rotary wings consisting of a first pair of rotary wings and a second pair of rotary wings, wherein the first pair of rotary wings is a pair of two rotary wings positioned on the front-half side of the frame and the

second pair of rotary wings is a pair of two rotary wings positioned on the back-half side of the frame, and wherein the four rotary wings are positioned inside the frame;

a drive device that drives the four rotary wings;

a control signal generation circuit that generates a control signal for causing the drive device to drive the four rotary wings, wherein the control signal generation circuit is stored in a waterproof case and the waterproof case is positioned between the first pair of rotary wings and the second pair of rotary wings;

and

an imaging camera, wherein the four rotary wings, the drive device, the waterproof case, and the imaging camera are integrated using the frame,

wherein an upper surface of the frame defines four apertures that correspond respectively with one of the four rotary wings, and each of the four apertures is partly covered by the frame;

to fly inside a tubular closed-type space extending in a direction other than a vertical direction with driving the four rotary wings while taking images inside the tubular closed-type space by means of the imaging camera.