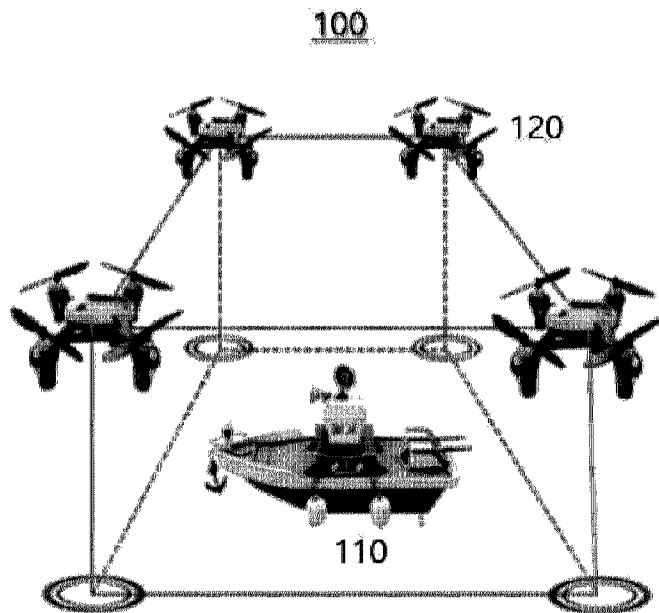




(22) Date de dépôt/Filing Date: 2020/11/25
(41) Mise à la disp. pub./Open to Public Insp.: 2021/10/17
(45) Date de délivrance/Issue Date: 2023/01/10
(30) Priorité/Priority: 2020/04/17 (KR10-2020-0046930)

(51) Cl.Int./Int.Cl. *G05D 1/10* (2006.01),
B63G 8/14 (2006.01), *B64C 19/00* (2006.01),
B64C 39/02 (2006.01)
(72) Inventeur/Inventor:
KIM, HYEONG MIN, KR
(73) Propriétaire/Owner:
PABLO AIR CO., LTD., KR
(74) Agent: AVENTUM IP LAW LLP

(54) Titre : VEHICULE MOBILE SANS PILOTE DE SURVEILLANCE ET SYSTEME LE COMPRENANT
(54) Title: UNMANNED MOVING VEHICLE FOR MONITORING AND SYSTEM INCLUDING SAME



(57) **Abrégé/Abstract:**

The present invention relates to an unmanned moving vehicle for monitoring and a system including the same and, more particularly, to a method of controlling an unmanned moving vehicle whose communication with a master unmanned device is disconnected. To this end, the unmanned moving vehicle system for monitoring includes a master unmanned device performing communication with a ground control system located on the ground; and an unmanned moving vehicle performing communication with the master unmanned device, flying in formation around the master unmanned device, and calculating a distance to other unmanned moving vehicle flying in formation when communication with the master unmanned device is disconnected.

ABSTRACT

The present invention relates to an unmanned moving vehicle for monitoring and a system including the same and, more particularly, to a method of controlling an unmanned moving vehicle whose communication with a master unmanned device is disconnected. To this end, the unmanned moving vehicle system for monitoring includes a master unmanned device performing communication with a ground control system located on the ground; and an unmanned moving vehicle performing communication with the master unmanned device, flying in formation around the master unmanned device, and calculating a distance to other unmanned moving vehicle flying in formation when communication with the master unmanned device is disconnected.

UNMANNED MOVING VEHICLE FOR MONITORING AND SYSTEM
INCLUDING SAME

5

BACKGROUND OF THE INVENTION

Field of the Invention

10 The present invention relates to an unmanned moving vehicle for monitoring and a system including the same and, more particularly, to a method of controlling an unmanned moving vehicle whose communication with a master unmanned device is disconnected.

15

Description of the Related Art

As interest in unmanned moving vehicles increases, the importance of developing related systems has been highlighted, and many studies on a single unmanned system have been
20 conducted. Since the unmanned moving vehicles can advantageously reduce human injury compared to manned vehicles and perform various tasks such as searching, reconnaissance, and mapping of dangerous areas, studies on using the unmanned moving vehicles in related fields has been
25 actively progressing. The unmanned vehicles are used for

searching, reconnaissance, etc., in the military field, a delivery service using drones is being developed in the transportation field by businesses such as Amazon, Google, Alibaba, etc., and uses are being developed in various industrial fields. In addition, the unmanned moving vehicles are actively used in fields of firefighting, photography, agriculture, etc. and used in fields of submarine topography, mapping, and coastal reconnaissance as unmanned floating boats, unmanned submarines, etc.

10 According to the five-year plan for unmanned vehicle development, the global market is expected to grow at an annual average of 22% (24.8 billion dollars in 2015 → 67.3 billion dollars in 2020) in terms of market trends. Not only companies with existing unmanned vehicle technology in advanced countries such as the United States and EU, but also IT companies such as Google and Chinese companies are actively investing in technology development and making results. In Korea, the investment is focused on the development of medium and large UAVs, but the investment on 20 the development of small UAVs is inadequate, whereby the technology for core parts of autonomous vehicles is inferior to advanced countries.

Currently, the unmanned moving vehicles are being used in various fields, and in particular, are used for monitoring 25 marine or terrestrial environments.

[Related Patent Document]

[Patent Document 1] Korean Patent No. 10-1881396 (Title
of the invention: Collaborative anti-drone system and drone
5 collaboration control method)

[Patent Document 1] Korean Patent No. 10-1895343 (Title
of the invention: Drone control method for collision
avoidance)

10

SUMMARY OF THE INVENTION

Accordingly, the present invention has been made keeping
in mind the above problems occurring in the related art, and
an objective of the present invention is to provide an
15 unmanned moving vehicle system for monitoring the ocean or
land while flying in formation.

Another objective of the present invention is to provide
a method by which unmanned moving vehicles are capable of
continuing monitoring when communication is disconnected
20 between a master unmanned device and the unmanned moving
vehicles that are in formation.

Another objective of the present invention is to provide
a method by which unmanned moving vehicles return to a
predetermined point when communication is disconnected

between a master unmanned device and the unmanned moving vehicles that are in formation.

Another objective of the present invention is to provide a method of calculating the distances of the unmanned moving
5 vehicle to other unmanned moving vehicles.

In order to achieve the objective, an unmanned moving vehicle system for monitoring is provided according to the present invention, the system including a master unmanned device performing communication with a ground control system
10 located on the ground; and an unmanned moving vehicle performing communication with the master unmanned device, flying in formation around the master unmanned device, and calculating a distance to other unmanned moving vehicle flying in formation when communication with the master
15 unmanned device is disconnected.

The effects according to the present invention are generated as follows.

The unmanned moving vehicle for monitoring according to the present invention can monitor the environment while
20 flying in formation, thereby increasing the scope of use, and reduce the cost by using the camera used for the existing mission without adding a separate sensor for collision avoidance.

In addition, according to the present invention, when
25 communication with the master unmanned device is disconnected,

the distance to the approaching unmanned moving vehicle can be calculated and the altitude of the unmanned moving vehicle can be changed when the calculated distance is within the predetermined distance, whereby there is an effect that can avoid collision with other unmanned moving vehicles.

According to one aspect of the invention, there is provided an unmanned moving vehicle system for monitoring, the system comprising:

a master unmanned device performing communication with a ground control system located on the ground; and

an unmanned moving vehicle performing communication with the master unmanned device, flying in formation around the master unmanned device, and calculating a distance to other unmanned moving vehicle flying in formation when communication with the master unmanned device is disconnected,

wherein the unmanned moving vehicle is configured in such a manner as to maintain a same altitude as the other unmanned moving vehicle in a state in which communication with the master unmanned device is connected, and to move to have an altitude different from the other unmanned moving vehicle until receiving a request to fly in formation with the other unmanned moving vehicle from the ground control system in a state in which communication with the master unmanned device is disconnected.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objectives, features, and other advantages of the present invention will be more clearly understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a view illustrating an unmanned moving vehicle system for monitoring surroundings according to an embodiment of the present invention;

FIG. 2 is a view illustrating an operation that the unmanned moving vehicle performs when communication between a master unmanned device and unmanned moving vehicles is disconnected according to an embodiment of the present invention;

5

FIG. 3 is a flowchart illustrating an operation that an unmanned moving vehicle performs according to an embodiment of the present invention; and

FIG. 4 is a diagram illustrating a process in which an unmanned moving vehicle performs a mission according to the

10

15

20

25

30

35

number of mission points according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

5

The foregoing and additional aspects of the present invention will become more apparent through preferred embodiments described with reference to the accompanying drawings. Hereinafter, it will be described in detail so that those skilled in the art can easily understand and reproduce the present invention through the embodiments.

FIG. 1 is a view illustrating an unmanned moving vehicle system for monitoring surroundings according to an embodiment of the present invention. Hereinafter, an unmanned moving vehicle system for monitoring an environment according to an embodiment of the present invention will be described in detail with reference to FIG. 1.

Referring to FIG. 1, the unmanned moving vehicle system 100 includes a master unmanned device 110 and multiple unmanned moving vehicles 120. In addition, the unmanned moving vehicle system 100 includes a ground control system.

The master unmanned device 110 performs communication with the ground control system, and transmits and receives information necessary for environmental monitoring. The master unmanned device 110 performs communication with

multiple unmanned moving vehicles 120 and performs control so that the unmanned moving vehicles perform environmental monitoring while flying in a predetermined area.

In connection with the present invention, the master
5 unmanned device 110 performs control so that the unmanned moving vehicles 120 maintain the same altitude while flying in formation.

The unmanned moving vehicles 120 maintain a certain distance interval on the basis of the master unmanned device
10 110. Each unmanned moving vehicle 120 has a safety radius in order to avoid collision with other unmanned moving vehicles flying in formation. When an obstacle or another unmanned moving vehicle approaches within a certain distance on the basis of the unmanned moving vehicle, the safety radius means
15 the distance required to avoid collision with the unmanned moving vehicle. Thus, the unmanned moving vehicle 120 moves to an altitude that is set to avoid collision when another unmanned moving vehicle approaches within the safe radius.

The present invention is shown that monitors the
20 surrounding environment using four unmanned moving vehicles, but is not limited thereto.

The unmanned moving vehicle 120 is equipped with a camera to identify specific issues using image information captured from the camera. For example, it is possible to
25 obtain an image of an illegal fishing boat from the captured

image information. According to the present invention, the unmanned moving vehicle 120 performs communication with the master unmanned device 110 and, if necessary, performs communication with other unmanned moving vehicles.

5 According to present invention, the unmanned moving vehicles 120 monitor the surrounding environment through collaboration. In this regard, specific details will be described below.

1. The unmanned moving vehicles receive a command to
10 switch to a mission mode from the master unmanned device.

2. The unmanned moving vehicles start monitoring while flying in formation around the master unmanned device.

3. When the unmanned moving vehicles detect a suspect object during monitoring, the unmanned moving vehicles turn
15 around and monitor the corresponding object.

4. A size of the monitored object (for example, illegal fishing boat) is identified, so that it is determined whether a help request signal is generated by other unmanned moving vehicles.

20 5. When the unmanned moving vehicle receiving the help request signal are currently on a mission, the unmanned moving vehicle first performs the current mission and then proceeds with collaboration with other unmanned moving vehicles.

25 6. The unmanned moving vehicle returns to formation on

the basis of the master unmanned device after finishing the mission.

Multiple unmanned moving vehicles communicate via Wi-Fi, and each unmanned moving vehicle includes a separate
5 telemetry for the purpose of emergency return in the case of emergency. Since the unmanned moving vehicles has a possibility of being shot down or falling during a mission, economic feasibility should also be considered. Therefore, according to the present invention, minimum mission equipment
10 is mounted in the unmanned moving vehicles, and for example, a camera is used when performing the mission. In a normal case, the camera is used for monitoring illegal fishing boats. In the case of communication disconnection with the master unmanned device, the unmanned moving vehicles may collide and
15 fall due to confusion with each other. Herein, it is possible to measure the distance between the unmanned moving vehicles through machine learning using the camera without a need for additional sensors such as Lidar.

Hereinafter, a machine learning method using a camera
20 according to the present invention will be described.

The distance between an unmanned moving vehicle and other unmanned moving vehicle is measured by perform learning using a vector such as $\mathbf{v} = [1/B \ 1/Bw \ 1/Bd \ C \ Cw \ Cb]$. Herein, B , Bw , and Bd indicate a height, width, and diagonal in the

bounding box, respectively; and C , Cw , and Cb indicate average height, average width, and average breadth, respectively. The average height, average width, and average breadth mean average values for the object. For example, the unmanned
5 moving vehicle stores average values for various objects, and in particular, the average height, average width, and average breadth for the objects. The unmanned moving vehicles use the stored average values to identify what the object is.

In addition, the present invention is configured to
10 estimate the exact distance to the object by performing learning to reduce an error through $\mathbf{v} = [1/B \ 1/Bw \ 1/Bd \ C \ Cw \ Cb, Eh, Ew, Eb \ r]$, in which Eh , Ew , and Eb indicate a height error, width error, and breadth error, respectively, which represent the difference between the estimated value
15 and the actual distance, and r indicates a compensation value for the error.

The actual distance is a value measured by a sensor such as a Lidar, etc. The actual distance of the object is input together with a photograph of the object, so that the
20 unmanned moving vehicle repeatedly performs learning on the received actual distance and photograph.

The estimated value means the distance to the object determined from the image of the object captured through the camera after the learning is completed. The error means a

difference between the actual distance and the estimated value. In addition, since the estimated value and the actual distance have three factors of height, width, and breadth, the compensation value for the error is set each for three
5 factors.

Herein, r is 1 when the error is within 10 cm, and r is -1 when the error exceeds 10 cm, whereby learning is performed to have a higher value as r accumulates. The reason for setting the standard to 10cm is because an error
10 within a minimum of several centimeters is desirable when performing estimation with a camera in order to avoid collision between the unmanned moving vehicles. Therefore, the standard is set to 10 cm, and r is set to a positive value of 1 when the error is estimated to be within 10 cm and
15 to a negative value of -1 when the error exceeds 10 cm, with respect to the estimated value after initial learning to represent the error. Accordingly, it is determined whether the distance is properly estimated. Herein, as r is accumulated, the learning is performed so that the
20 accumulated value increases to a positive value.

To further explain, the present invention uses $\mathbf{v} = [1/B$
 $1/B_w \ 1/B_d \ C \ C_w \ C_b]$. When determining the object in the image, a bounding box is put around the detected object. Herein, B_h , B_w , and B_d indicate the height, width, and
25 diagonal length of the bounding box, respectively. C_h , C_w ,

and C_b indicate average height, average width, and average breadth, as described above, and are used when determining what the corresponding detected object is. For example, it is assumed that when the detected object is a human, $C_h = 175$ 5 cm, width = 55 cm, and breadth = 30 cm, and when the object is a car, $C_h = 160$ cm, $C_w = 180$ cm, and $C_b = 400$ cm. When performing learning, learning on distance estimation is performed through the corresponding vector and the actual distance (value). Herein, it is difficult to determine 10 whether the distance is accurately estimated with only the corresponding vector because there is no feedback.

Therefore, according to the present invention, ten factors are used such as in $[1/B \ 1/B_w \ 1/B_d \ C \ C_w \ C_b, E_h, E_w, E_b \ r]$, in which the error values between the actual values 15 and the estimated values and the compensation values for the error values are used. Accordingly, it is possible to accurately determine the distance by performing double learning, in such a manner as to compensate the error value for the estimated value and feedback the same.

20 Considering the above vector as an input layer, the learning is performed through hidden layers. Through such a configuration, the unmanned moving vehicle measures the distance to an object and creates a route that is capable of avoiding collision, whereby the unmanned moving vehicle may 25 avoid collision and return to the home safely. The input

layer and hidden layers are used for learning. The input layer means an input value, and in the present invention, means a vector. The learning is performed through the hidden layers, the photograph is determined through the corresponding layer, and the learning is performed to estimate the distance. As the number of layers increases, the intensity of learning increases.

FIG. 2 is a view illustrating an operation that the unmanned moving vehicle performs when communication between a master unmanned device and unmanned moving vehicles is disconnected according to an embodiment of the present invention. Hereinafter, when communication between the master unmanned device and the unmanned moving vehicles is disconnected according to an embodiment of the present invention, an operation performed in the unmanned moving vehicle will be described in detail with reference to FIG. 2.

In step S200, when communication between the master unmanned device and the unmanned moving vehicles is disconnected, the unmanned moving vehicles share information with each other using Wi-Fi, and change from a decentralized type in which each unmanned moving vehicle individually calculates position commands and states, to a centralized type in which the ground control system controls the unmanned moving vehicles.

In step S202, the ground control system measures the

position of each unmanned moving vehicle using GPS information provided from the unmanned moving vehicles.

In step S204, the unmanned moving vehicles move to an altitude that is set before control information is received
5 from the ground control system. That is, the unmanned moving vehicles are located at different altitudes to avoid collision with each other.

In step S206, the ground control system requests unmanned moving vehicles to move to the calculated location
10 of each unmanned moving vehicle and fly in formation, thereby performing environmental monitoring while avoiding collision with each other on the basis of the calculated location information. The unmanned moving vehicles maintain a certain distance while flying in formation.

15 In step S208, the unmanned moving vehicles flying in formation have an altitude matched to each other. In other words, when the unmanned moving vehicles receive a request to perform monitoring while flying in formation from the ground control system, the unmanned moving vehicles move to have the
20 same altitude.

In step S210, the ground control system creates a virtual point in the center of the flight formation to replace the master unmanned device, calculates the position command in real time on the basis of the created virtual
25 point, and controls the unmanned moving vehicles to perform

monitoring in the calculated position.

As described above, according to the present invention, when the unmanned moving vehicles are disconnected from the master unmanned device, the unmanned moving vehicles move to
5 have different altitudes from each other to avoid collision with each other, and move to have the same altitude to each other when receiving a request to fly in formation from the ground control system.

In addition, the present invention creates a virtual
10 point instead of the master unmanned device located at the center of the flight formation and controls the movements of unmanned moving vehicles on the basis of the created virtual point. To this end, the ground control system creates the final position of the master unmanned device as the virtual
15 point, or creates the virtual point using unmanned moving vehicle GPS information provided from the unmanned moving vehicles. The unmanned moving vehicles return to home when receiving a request to return from the ground control system.

According to the present invention, when communication
20 between the unmanned moving vehicles and the master unmanned device is disconnected, flight formation is controlled to change from a decentralized-type control method to a centralized-type control method. According to the decentralized-type control method, each entity (unmanned
25 moving vehicle) performs independent duties without a master

transmitting control commands, whereas according to the centralized-type control method, the master generates and transmits all control commands and other entities perform their duties through the received commands.

5 According to an initial control method configured through Wi-Fi, although a master unmanned device is the center point of an unmanned moving vehicle formation, the master unmanned device simply transmits its own position, and position commands for each unmanned moving vehicle and the
10 master unmanned device are calculated individually. Accordingly, when Wi-Fi is cut off due to bad weather, which is the most common at sea, the master unmanned device may return smoothly, but four unmanned moving vehicles flying in formation may undergo collision and falling-down during
15 returning.

Therefore, the present invention proposes an algorithm to safely return to home and minimize loss due to fall. Herein, the algorithm is controlled in such a way to generate and transmit all position commands by not each unmanned
20 moving vehicle, but the ground control system (centralized type).

Therefore, a role of the master unmanned device and a role of the ground control system acting in an emergency case are clearly different from each other. In other words, in a
25 normal case, the master unmanned device performs control on

movement of unmanned moving vehicles in order to minimize the load on the ground control system. Therefore, according to the present invention, a decentralized-type control method is selected in order to efficiently drive all processors as much
5 as possible, and change to a centralized control method occurs only in the case of emergency. In addition, the ground control system using a relatively high-performance computer is set as the master in the case of emergency.

More specifically, in a normal case, the master unmanned
10 device does not generate a command and shares only the location information with the unmanned moving vehicles, and the unmanned moving vehicles independently generate the command. On the contrary, in case of emergency, the ground control system generates command values and transmits the
15 generated command values to the unmanned moving vehicles. Therefore, the role of the ground control system in the case of emergency is different from that of the master unmanned device in a normal case.

FIG. 3 is a flowchart illustrating an operation that an
20 unmanned moving vehicle performs according to an embodiment of the present invention. Hereinafter, an operation performed by an unmanned moving vehicle according to an embodiment of the present invention will be described in detail with reference to FIG. 3.

25 In step S300, the unmanned moving vehicle follows the

position of the master unmanned device and moves according to a movement of the master unmanned device. Specifically, the unmanned moving vehicle moves according to the movement of the master unmanned device in a state that maintains a
5 constant distance from the master unmanned device.

In step S302, the unmanned moving vehicle switches to a mission mode to perform a mission.

In step S304, the unmanned moving vehicle determines whether a target to be monitored is detected. When the
10 target is captured, the operation moves to the next step.

In step S306, the unmanned moving vehicle determines whether a risk occurs when monitoring the target. Whether the risk occurs is determined by determining whether the target is a floating object or a legal fishing boat (risk
15 level 0), the target is a small illegal fishing boat (risk level 1), and the target is a large illegal fishing boat (risk level 2). To this end, the unmanned moving vehicle may receive information on the legal fishing boats from the ground control system or the master unmanned device.

20 In step S308, the unmanned moving vehicles continue to monitor the target when the target monitoring is at low risk. In other words, in the case of risk level 0 or risk level 1, the unmanned moving vehicle alone monitors the target.

In step S310, when the target monitoring is at high risk,
25 the unmanned moving vehicles generate a signal to attempt a

collaboration request and transmit the same to other unmanned moving vehicle.

In step S312, when the unmanned moving vehicles receive a collaboration response signal from the other unmanned moving vehicle, the unmanned moving vehicle performs the mission in collaboration with the other unmanned moving vehicle, whereas when the unmanned moving vehicle does not receive the collaboration response signal from the other unmanned moving vehicle, the unmanned moving vehicle performs the mission alone.

Of course, in the case that the unmanned moving vehicle receive a request for mission collaboration from other unmanned moving vehicle, when the unmanned moving vehicle is currently performing the mission, the unmanned moving vehicle completes the mission and then moves to the vicinity of the other unmanned moving vehicle, thereby performing the mission in collaboration. Of course, when the unmanned moving vehicle is not currently performing the mission, the unmanned moving vehicle moves near the other unmanned moving vehicle and performs the mission in collaboration. In other words, the unmanned moving vehicle currently performing its mission first completes the mission and then moves near the other unmanned moving vehicle, and then performs the mission requested from the other unmanned moving vehicle or returns to the base formation which is the original position.

FIG. 4 is a diagram illustrating a process in which an unmanned moving vehicle performs a mission according to the number of mission points according to an embodiment of the present invention.

5 When there is only one mission point, one of the unmanned moving vehicles flying in formation performs the mission, and when there are two mission points, two unmanned moving vehicles of the unmanned moving vehicles flying in formation perform the mission. When there are three mission
10 points, three unmanned moving vehicles of the unmanned moving vehicles flying in formation perform the mission, and when there are four mission points, all of the unmanned moving vehicles flying in formation perform the mission. Of course, when there is no mission point, the unmanned moving vehicles
15 fly in formation on the basis of the master unmanned device, and when communication with the master unmanned device is disconnected, the unmanned moving vehicles fly in formation on the basis of a virtual point.

The present invention has been described with reference
20 to one embodiment shown in the drawings, but this is merely exemplary, and those skilled in the art will understand that various modifications and other equivalent embodiments are possible therefrom.

WHAT IS CLAIMED IS:

1. An unmanned moving vehicle system for monitoring, the system comprising:

5 a master unmanned device performing communication with a ground control system located on the ground; and

an unmanned moving vehicle performing communication with the master unmanned device, flying in formation around the master unmanned device, and calculating a distance to other
10 unmanned moving vehicle flying in formation when communication with the master unmanned device is disconnected,

wherein the unmanned moving vehicle is configured in such a manner as to maintain a same altitude as the other unmanned moving vehicle in a state in which communication with the master
15 unmanned device is connected, and to move to have an altitude different from the other unmanned moving vehicle until receiving a request to fly in formation with the other unmanned moving vehicle from the ground control system in a state in which communication with the master unmanned device is disconnected.

20

2. The system of claim 1, wherein the unmanned moving vehicle is configured in such a manner as to maintain a same altitude as the other unmanned moving vehicle in a state in which communication with the master unmanned device is
25 connected, and to move to have an altitude different from the other unmanned moving vehicle until receiving a request to fly in formation with the other unmanned moving vehicle from the ground control system in a state in which communication with the master unmanned device is disconnected.

30

3. The system of claim 2, wherein the actual distance is a value measured using a sensor and input to the unmanned moving vehicle together with a photograph of the object, and the estimated value is a value calculated from an image of the
35 object photographed through the camera.

4. The system of claim 3, wherein the compensation value of the error is calculated in such a manner as to be increased by 1 when the error is within a predetermined value and to be decreased by 1 when the error exceeds the predetermined value.

5

5. The system of claim 4, wherein the unmanned moving vehicle rejects a request for collaboration, which is transmitted from the other unmanned moving vehicle, when the unmanned moving vehicle is currently monitoring a target.

10

6. The system of claim 5, wherein the unmanned moving vehicle makes a request for collaboration to the other unmanned moving vehicle, depending on a risk level of the target being monitored, the risk level for the target being determined according to whether the target is a floating object or depending on a size of the target.

15

7. The system of claim 2, wherein the unmanned moving vehicle receives a request to fly in formation with the other unmanned moving vehicle from the ground control system, and flies in formation with the other unmanned moving vehicle on the basis of a virtual point provided from the ground control system.

20

FIG.1

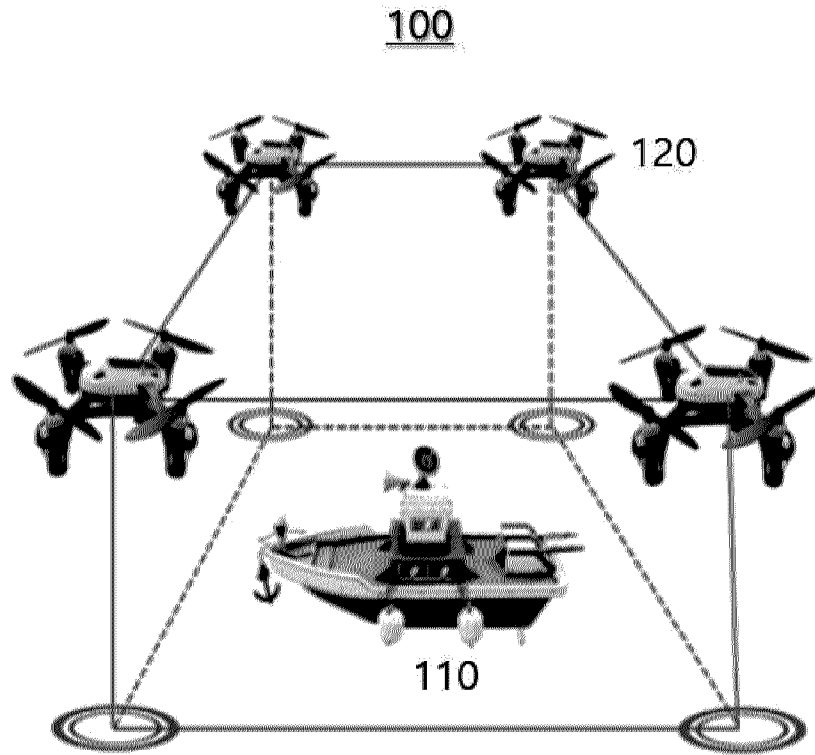


FIG.2

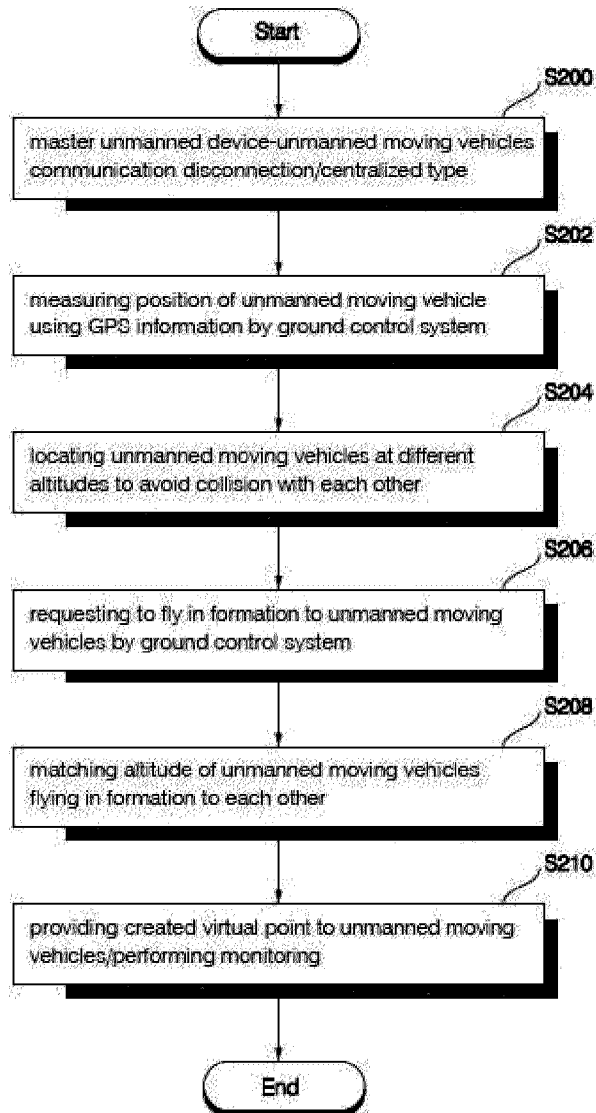


FIG.3

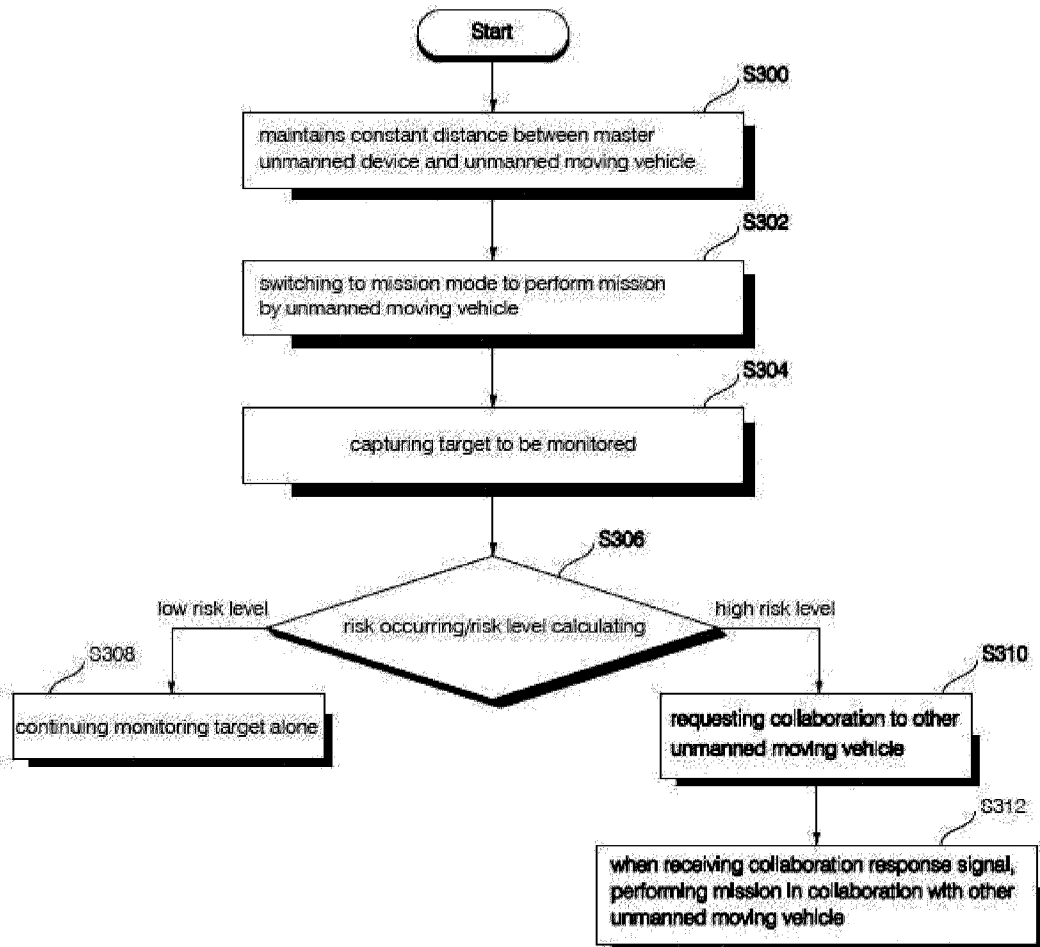
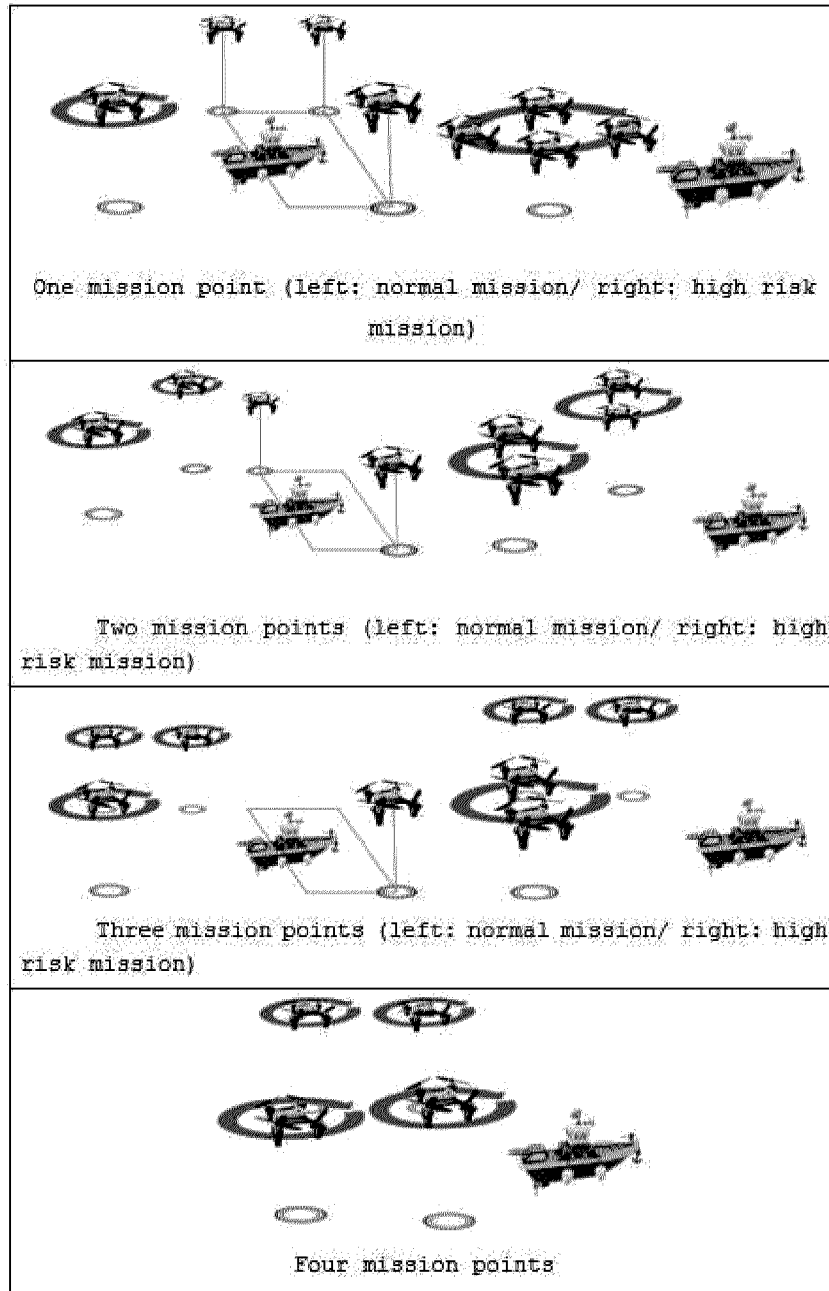
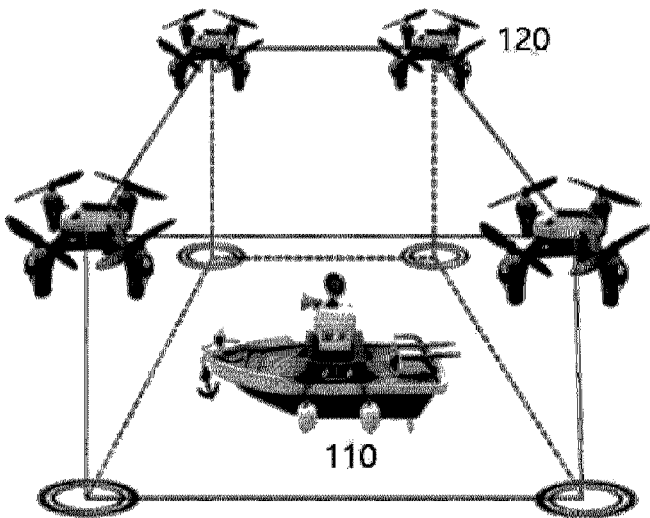


FIG 4



100



120

110