

Interceptor drone

The invention relates to an interceptor drone.

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Numerous systems are known from the prior art for hindering or preventing the unwanted operation of flying drones. In addition to disruptive systems, in which the functions of flying drones are disabled, for example, by shooting at them, 10 there are also known solutions in which the control of the flying drones can be taken over or which force the flying drones to make a controlled landing. With the former systems, there is a risk that the flying drones or parts of flying drones will land uncontrollably, endangering people and 15 infrastructure. Such systems are therefore particularly suitable for use in uninhabited areas where there is little danger from uncontrolled falling drones and their parts. Such systems are not suitable for use near civilian infrastructure such as airports and stadiums. In such cases, the latter 20 systems are used, in which the drones are landed in a controlled manner.

Known systems for the controlled landing of flying drones require the control of the respective flying drone to be 25 influenced. For this purpose, it is necessary for known systems to be adapted to commonly used flying drones in order to exploit known vulnerabilities of the respective flying drone type. Therefore, these systems cannot be used universally against any flying drone.

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The object of the invention is therefore considered to be improving the systems known from the prior art in such a way

that a controlled landing of flying drones of any flying drone system is made possible.

According to the invention, this object is achieved by means of an interception drone with a drone base body and multiple drive devices arranged around the circumference of the drone base body, wherein the drive devices are arranged and oriented on the drone base body in such a way that the interception drone can be driven and steered by the drive devices in a flight direction along a flight trajectory, wherein the interception drone comprises a capture net, wherein the capture net is arranged in or on the drone base body, wherein the capture net is secured to the drone base body by means of an elongated, flexible securing means of the capture net, wherein the capture net comprises drive means by which the capture net can be accelerated away from the drone base body in the flight direction. By using the capture net, the flying drone to be intercepted can be captured in flight with the capture net and landed in a controlled manner, since the capture net with the flying drone "captured" therein is connected to the interceptor drone via the securing means. The capture net is advantageously also designed to be flexible and is formed by ropes or lines.

Advantageously, the securing means is a rope. In order to be able to safely "capture" flying drones even at high relative speeds between the interception drone and the flying drone, it is advantageously provided that the securing means has a length of at least 10 m.

To "capture" a flying drone, the interceptor drone is advantageously steered automatically in the direction of the

flying drone to be intercepted, and then, at a predetermined distance from the flying drone, the drive means are activated and the capture net is fired away from the drone base body in the direction of the flying drone.

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Advantageously, the interceptor drone or the drive device are steered and controlled in such a way that the interceptor drone approaches the drone to be intercepted from above in the direction of the ground. Since the flying drone to be

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intercepted is unable to fly after being "captured" with the capture net and therefore the capture net and the flying drone accelerate towards the ground due to the force of gravity, this prevents the flying drone and the capture net from initially falling uncontrollably towards the ground over a

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long distance, determined in particular by the length of the securing means, until the capture net with the flying drone hangs below the interceptor drone with the securing means taut and can be held or slowed down by the interceptor drone.

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Advantageously, the drone base body is cylindrical in shape, with the cylinder height being greater than the cylinder diameter. The drive devices are advantageously arranged symmetrically around the circumference of the drone base body. Advantageously, the interception drone comprises at least four

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drive devices.

According to the invention, it is advantageously provided that the capture net is arranged in a drone portion of the drone base body that is at the front in the flight direction. In this way, the capture net can be accelerated away from the base body particularly easily in the direction of flight.

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However, it is also possible and provided for in the invention

that the capture net is arranged in the area of the drive devices on a side surface of the base body.

5 In order to be able to brake the capture net with the flying drone quickly and safely and to land it in a controlled manner, the invention provides that the interceptor drone comprises a parachute, wherein the parachute is arranged in or on the drone base body in a drone portion of the drone base body that is rearward in the flight direction, wherein the
10 parachute is secured to the drone base body by at least one parachute tether, wherein the parachute comprises an deployment device by means of which the parachute can be opened away from the drone base body against the flight direction. Advantageously, the opening means are controlled in
15 such a way that the parachute slows down the interception drone as soon as the capture net reaches the flying drone. In this way, an uncontrolled fall can be avoided, particularly when the flying drone is approaching from above towards the ground. Advantageously, the capture net and the parachute are
20 activated simultaneously or immediately after each other and accelerated away from the drone base body.

The deployment device advantageously comprises a deployment charge to pyrotechnically accelerate and open/deploy the
25 parachute away from the drone base body. According to the invention, the deployment device may alternatively or additionally to the charge also have a pull-up parachute which is connected to the parachute via multiple lines and accelerates the parachute away from the drone base body. The
30 parachute is advantageously connected to the drone base body by lines.

In order to be able to land the interception drone with the captured drone in a controlled manner, the invention provides that at least one line of the parachute is connected to a line pull actuator arranged on the drone base body, wherein the line can be pulled in and released via the line pull actuator in order to control the parachute. The line pull actuator may be, for example, a winch.

However, it is also possible, as an alternative or in addition to control by means of a line pull actuator, to control the landing by means of suitable control of the drive devices.

In order to be able to quickly and easily replace the parachute with a new, pre-folded parachute after it has been deployed, the invention provides that the parachute can be arranged inside a parachute bag of the parachute and that the parachute bag and the drone base body have matching connecting means so that the parachute bag can be detachably secured to the drone base body.

Advantageously, the invention provides that the drive devices are arranged in a central drone portion of the drone base body between the front drone portion and the rear drone portion on the drone base body. In this way, the capture net and the parachute can be easily accelerated away from the drone base body, avoiding contact with the drive devices.

In order to be able to easily arrange the capture net in the front drone portion, the drive devices in the central drone portion, and the parachute in the rear drone portion, the invention provides that the drone base body has an elongate

shape in the flight direction. The drone base body can advantageously be cylindrical or rocket-shaped.

5 In a particularly advantageous shape of the drone base body, the length of the drone base body in the flight direction is greater than the largest extension of the drone base body transverse to the flight direction.

10 In order to accelerate the capture net with the drive means in the direction of the flying drone to be intercepted, the invention provides that the drive means comprise at least one pyrotechnic propellant charge. In this way, sufficient acceleration can be achieved to safely "catch" flying drones using the capture net even at a distance of, for example, 10 m
15 from the intercepting drone.

Advantageously, the invention provides that the capture net comprises acceleration masses arranged on a circumference of the capture net, wherein the acceleration masses can be
20 accelerated by the drive means. By using the acceleration masses, the essentially flexible capture net can be safely accelerated away from the drone body. The use of the acceleration masses also ensures that the capture net wraps around the flying drone as soon as the capture net reaches the
25 flying drone.

In addition, the acceleration masses can advantageously be accelerated away from the drone body by the drive means in such a way that the capture net is pulled up by the
30 acceleration masses. For example, the acceleration masses arranged around the circumference of the capture net can be accelerated along different acceleration axes, with the

acceleration axes intersecting in the flight direction in or behind the interception drone.

5 To propel the interception drone, it is advantageous that the drive devices are propeller drives. Using suitable propeller drives, the interception drone can advantageously be accelerated to a speed of up to 200 km/h.

10 The propeller drives are advantageously electrically driven and have electric motors for this purpose. The electrical energy required to operate the electric motors is advantageously provided by batteries of the interceptor drone, which are arranged within the drone base body according to the invention. Advantageously, the batteries are accumulators.

15 For automated control of the interceptor drone, the invention provides that the interceptor drone comprises a sensor device, wherein the sensor device is arranged in the front drone portion of the drone base body on the drone base body. The sensor device is advantageously connected to a control device of the interceptor drone via a data link, which can process sensor signals from the sensor device. The control device is advantageously connected to the drive devices in an electrically conductive and/or data-conductive manner in order to be able to control the drive devices independently of one another and thus to specify and adjust the flight trajectory or flight direction and flight speed.

20 Advantageously, according to the invention, the sensor device has at least one flight camera for optically detecting the surroundings of the interceptor drone. The flight camera is advantageously an infrared camera. In order to be able to

detect the flight drone to be controlled as well as possible and in different flight positions with the flight camera, the invention provides that the flight camera has a gimbal suspension that is secured to the drone base body. It is advantageous if the alignment of the flight camera in the gimbal suspension can be predetermined. For this purpose, the gimbal suspension advantageously has electric motor drives. These can be controlled by the control device, for example.

10 In order to activate the drive means at a suitable time and at a suitable distance between the interceptor drone and the drone to be intercepted, the invention provides that the sensor device has a distance measuring device for determining the distance between the interceptor drone and an object in the vicinity of the interceptor drone. The distance measuring device may advantageously be a laser distance measuring device.

The invention also relates to a ground station for an interception drone as described above, wherein the ground station comprises a receiving base body that can be set up on the ground and has a receiving opening, wherein the receiving base body is adapted to the interceptor drone in such a way that the interceptor drone can be received by the receiving base body through the receiving opening with a drone portion at the rear in the flight direction. The ground station allows the interceptor drone to be held in an advantageous launch position and kept ready for an interception mission.

30 In order to enable the interceptor drone to be aligned in the ground station, which facilitates a vertical launch of the interceptor drone, particularly when using the advantageous

cylindrical design of the drone base body, the invention provides that the receiving base body is designed such that a longitudinal axis of the interception drone, which is arranged in sections in the receiving base body, is oriented

5 perpendicular to the ground when the receiving base body is standing on the ground as intended.

Advantageously, the invention provides that the ground station and the interceptor drone have electrical connection terminals

10 that are adapted to each other, via which the interceptor drone can be connected to the ground station in an electrically conductive manner. Advantageously, the connection terminals are arranged on the circumference of the drone base body and the receiving base body in such a way that the

15 connection terminals make contact when the interception drone is arranged in the receiving base body as intended. The electrical connection terminals can advantageously be used to charge the interception drone's batteries.

20 The invention also relates to an interception system with at least one interception drone as described above and with at least one ground station as described above, wherein the interception system has at least one sensor station and a master computer, wherein the sensor station has at least one

25 ground camera for optically detecting the surroundings of the sensor station, and wherein the master computer is connected to the at least one sensor station and the at least one interception drone for data transmission. The sensor stations advantageously comprise multiple infrared cameras in order to

30 monitor the entire airspace for possible interception targets. In addition, the sensor stations each advantageously comprise a detail camera, the alignment and focus of which are

advantageously adjustable. In this way, after a rough detection of a potential interception target by the infrared cameras, the controllable detailed camera can be oriented by the master computer in the direction of the interception

5 target and checked to see whether it is a flying drone to be intercepted. Once this has been determined by the master computer, an interception drone is launched by the master computer and guided towards the flying drone to be intercepted, with the flight trajectory being specified and
10 determined by the master computer. As soon as the interceptor drone is at a predetermined distance from the drone to be intercepted, the control unit of the interceptor drone takes over further control and specification of the flight trajectory based on the sensor data from the sensor device of
15 the interceptor drone.

Further advantageous embodiments of the interception drone, the ground station, and the interception system according to the invention are explained in more detail on the basis of the
20 embodiments shown in the figures.

The figures show in:

Figure 1 a schematic representation of an interception drone
25 according to the invention,

Figure 2 a schematic representation of an interception drone arranged in a ground station according to the invention, and

30 Figure 3 a schematic representation of a sensor station of an interception system according to the invention.

Figures 1 and 2 schematically show an interception drone 1 with a cylindrical drone base body 2 and multiple drive devices 3 arranged around the circumference of the drone base body 2. The drive devices 3 are electrically driven propeller drives 3'. The propeller drives 3' are arranged and oriented in a central drone portion 4 on the drone base body 2 in such a way that the interception drone 1 can be driven and steered by the propeller devices 3' in a flight direction 5 along a flight trajectory.

The interception drone 1 comprises a capture net arranged in the drone base body 2 and therefore not visible. The capture net is arranged in a drone portion 6 of the drone base body 2 at the front in the flight direction 5. The capture net has acceleration masses 7 arranged on a circumference of the capture net, which are mounted in receiving devices 8 arranged on the drone base body 2. Drive means, which are not shown, are also arranged within the receiving devices 8 in order to be able to accelerate the acceleration masses 7 and thus the capture net away from the drone base body.

The interception drone 1 also comprises a parachute, which is also arranged in the drone base body 2 and is therefore not visible. The parachute is arranged in a drone portion 9 of the drone base body 2 located behind the flight direction 5 in the drone base body 2. In the embodiment, the parachute is arranged behind a cover 10 and can be opened away from the drone base body 2 in the opposite direction to the flight direction 5 using a deployment device that is also not visible.

The interceptor drone 1 also comprises a sensor device 11 arranged in the front drone portion 6 of the drone base body 2 on the drone base body 2. The sensor device 11 comprises a flight camera 12 for optically detecting the surroundings of the interception drone 1 and a distance measuring device 13 for determining a distance between the interception drone 1 and an object in the surroundings of the interception drone 1.

In the situation shown in Figure 2, the interceptor drone 1 is arranged in a receiving base body 14 of a ground station 15. The receiving base body 14 of the ground station 15 is set up on the ground 16 and is supported on the ground 16 by struts 17.

The interceptor drone 1 is arranged and stored in sections within the receiving base body 14 of the receiving unit 15 through a receiving opening 18 in the receiving base body 14, with the rear drone portion 6 facing in the flight direction 5. A longitudinal axis 19 of the interception drone 1 is oriented perpendicular to the ground so that the interception drone 1 can be launched vertically from the ground station 15.

The ground station 15 and the interceptor drone 1 have matching electrical connection terminals 20, 21, via which the interceptor drone 1 is electrically connected to the ground station 15. The electrical connection ports 20, 21 can be used to charge batteries (not shown) of the interception drone 1.

Figure 3 schematically shows a sensor station 22 of an interception system according to the invention. The sensor station 22 comprises multiple ground cameras 23 for optically detecting the surroundings of the sensor station 22. Multiple

ground cameras 23 designed as infrared cameras 24 are arranged around a ground camera 23 designed as a detail camera 25. The alignment and focus of the detail camera 25 are adjustable.

CLAIMS

1. Interceptor drone (1) with a drone base body (2) and with
5 multiple drive devices (3) arranged around the circumference
of the drone base body (2), wherein the drive devices (3) are
arranged and oriented on the drone base body (2) in such a way
that the interception drone (1) can be driven and steered by
the drive devices (3) in a flight direction (5) along a flight
10 trajectory, wherein the interception drone (1) comprises a
capture net, wherein the capture net is arranged in or on the
drone base body (2), wherein the capture net is secured to the
drone base body (2) by means of an elongated, flexible
securing means of the capture net, wherein the capture net
15 comprises drive means by which the capture net can be
accelerated away from the drone base body (2) in the flight
direction (5).

2. Interceptor drone according to claim 1, characterized in
20 that the capture net is arranged in a drone portion (6) of the
drone base body (2) that is located at the front in the flight
direction (5).

3. Interceptor drone (1) according to claim 1 or claim 2,
25 characterized in that the interceptor drone (1) comprises a
parachute, wherein the parachute is arranged in or on the
drone base body (2) in a drone portion (9) of the drone base
body (2) at the rear in the flight direction (5) , wherein the
parachute is secured to the drone base body (2) by at least
30 one parachute tether, wherein the parachute comprises an
deployment device by means of which the parachute can be

opened away from the drone base body (2) in the opposite direction to the flight direction (5).

4. Interceptor drone (1) according to any one of the preceding claims, characterized in that the drive devices (3) are arranged in a central drone portion (4) of the drone base body (2) between a front drone portion (6) and a rear drone portion (9) on the drone base body (2).

5. Interceptor drone (1) according to any one of the preceding claims, characterized in that the drone base body (2) has an elongate shape in the flight direction (5).

6. Interceptor drone (1) according to claim 5, characterized in that a length of the drone base body (2) in the flight direction (5) is greater than a largest extension of the drone base body (2) transverse to the flight direction (5).

7. Interceptor drone (1) according to any one of the preceding claims, characterized in that the drive means comprise at least one pyrotechnic propellant charge.

8. Interceptor drone (1) according to any one of the preceding claims, characterized in that the capture net comprises acceleration masses (7) arranged on a circumference of the capture net, wherein the acceleration masses (7) can be accelerated by the drive means.

9. Interceptor drone (1) according to any one of the preceding claims, characterized in that the drive devices (3) are propeller drives (3').

10. Interceptor drone (1) according to any one of the preceding claims, characterized in that the interceptor drone (1) comprises a sensor device (11), wherein the sensor device (11) is arranged in the front drone portion (5) of the drone base body (2) on the drone base body (2).

11. Interceptor drone (1) according to claim 10, characterized in that the sensor device (11) comprises at least one flight camera (12) for optically detecting the surroundings of the interceptor drone (1).

12. Interceptor drone (1) according to claim 10 or claim 11, characterized in that the sensor device (11) comprises a distance measuring device (13) for determining a distance between the interceptor drone (1) and an object in the surroundings of the interceptor drone (1).

13. Ground station (15) for an interceptor drone (1) according to any one of the preceding claims, wherein the ground station (15) comprises a receiving base body (14) that can be set up on the ground (16) and comprises a receiving opening (18), wherein the receiving base body (14) is adapted to the interceptor drone (1) such that the interceptor drone (1) can be received by the receiving base body (14) through the receiving opening (18) with a drone portion (9) located behind it in the flight direction (5).

14. Ground station (15) according to claim 13, characterized in that the receiving base body (14) is designed such that a longitudinal axis (19) of the interception drone (1) arranged in sections in the receiving base body (14) is oriented

perpendicular to the ground (16) when the receiving base body (14) is standing on the ground (16) as intended.

15. Interception system, comprising at least one interception
5 drone (1) according to any one of claims 1 to 12 and at least
one ground station (15) according to claim 13 or claim 14,
wherein the interception system comprises at least one sensor
station (22) and a master computer, wherein the sensor station
(22) comprises at least one ground camera (23) for optically
10 detecting the surroundings of the sensor station (22), and
wherein the master computer is connected to the at least one
sensor station (22) and the at least one interception drone
(1) for data transmission.