

FIXED-WING UNMANNED AERIAL VEHICLE TAKE-OFF AND LANDING SYSTEM AND METHOD THEREOF

TECHNICAL FIELD

[0001] The present invention relates to the technical field of an unmanned aerial
5 vehicle (UAV) take-off and landing apparatus, and in particular, to a fixed-wing
unmanned aerial vehicle take-off and landing system and a method thereof.

BACKGROUND

[0002] Currently, the conventional ways for fixed-wing UAV to take off are
taxiing takeoff, vertical takeoff, air delivery, ballistic catapult takeoff and
10 hand-launched takeoff. Compared to takeoff, UAV recovery is a phase which is
more complicated and easier to have malfunctions, and whether to land safely has
become an important index for evaluating UAV performance, and the current UAV
recovery manner mainly include parachute landing recovery, net capturing recovery,
undercarriage pulley landing and aerial pickup recovery.

15 [0003] In the prior art, takeoff and recovery of fixed-wing UAV system are
usually mutually independent systems, moreover, one take-off apparatus or recovery
system only can satisfy one single model of fixed-wing UAV for use, the using cost
is relatively high, and the adaptability is relatively low, and it is difficult to meet the
auxiliary demands for take-off and landing of the current fixed-wing UAV.

20 SUMMARY

[0004] In view of the disadvantages of the prior art, the applicant provides a
fixed-wing UAV take-off and landing system with a reasonable structure and a
method thereof, so as to satisfy take-off and landing requirements of fixed-wing
UAVs with different sizes and models, improve an attendance efficiency of the UAV
25 and reduce the space occupied by the UAV take-off and landing apparatus.

[0005] The technical solutions adopted by the present invention are described as
follows:

[0006] there is provided a fixed-wing UAV take-off and landing system,

including: a base, where a front end of the base is arranged with an energy storage device via a boss, the energy storage device includes an outer sleeve which is fixedly arranged on an upper surface of the boss, a catapult, which slides along an outer sleeve, is nested within the outer sleeve, a front end of the catapult is arranged with

5 an adjustable launcher, the adjustable launcher includes a launch rack, two sides of which are respectively rotatably connected to adjusting frames, inner sides of each adjusting frame are respectively fixedly connected to UAV brackets, rear-top sides of each adjusting frame are arranged with check frames; a rear end face of the outer sleeve is arranged with a baffle plate with a round hole formed in the middle, a

10 lower side of the baffle plate is connected to a groove frame arranged at the rear end face of the boss, the groove frame is provided with a locking mechanism, the catapult is connected to the baffle plate via a spring, an end of the catapult penetrates through the round hole of the baffle plate and snaps into the locking mechanism;

[0007] a rear end face of the catapult is connected to a drive control mechanism

15 via a first rope, the drive control mechanism includes a take-up reel driven by a servomotor arranged in the middle of an upper surface of the base, a primary wiring groove is provided along the circumference of the take-up reel for winding the first rope, a secondary wiring groove being concentric with the primary wiring groove extends axially along an outer end surface of the take-up reel and is wound with the

20 second rope, and the other end of the second rope is connected to the locking mechanism;

[0008] a rear end face of the catapult is connected to an arresting recovery mechanism via a third rope, the arresting recovery mechanism includes tilt supports connected to both sides of a tail end of the base, a light-weight pulley is arranged at

25 an upper end of the tilt support via a shaft, legs are arranged on both sides of a lower portion of the tilt support, an arresting rope is wound on the two legs and the light-weight pulley and arranged in a triangular shape, a rear end of the arresting rope is connected to a tension sensor, and the other end of the tension sensor is connected to the third rope;

30 [0009] an arresting net is hoisted on a bottom surface of the boss; a signal transmission and control device is arranged in the middle of the upper surface of the base, where the signal transmission and control device includes a servo drive

arranged in the middle of the upper surface of the base for controlling rotation of the servomotor, an upper computer configured to calculate and transmit dynamic parameters, and a motion control card configured to receive a motion control program from the upper computer and transmit signals to the servo drive.

5 [0010] The locking mechanism includes two locking cams arranged oppositely, where, lower ends of the two locking cams are respectively fixed to the groove frame via a revolute pair, middle portions of the two locking cams are connected via a tension spring, upper ends of the two locking cams form a ring communicated with the round hole on the baffle plate, and an end of the catapult penetrates through the
10 round hole of the baffle plate and snaps into the ring.

[0011] The groove frame is L-shaped and includes a vertical plane and a horizontal plane extending at the bottom, the two locking cams are arranged in the middle of the vertical plane, four corners of the vertical plane are respectively arranged with a wire guiding wheel, two wire guiding wheels are arranged on the
15 horizontal plane at intervals, top ends of the two locking cams are respectively fixed with two joints of the second rope via eyebolts, the two joints are respectively wound around the wire guiding wheel on the vertical plane from both sides, respectively wound around the two wire guiding wheel on the horizontal plane, converged into a single rope through a latch and then wound into the secondary
20 wiring groove.

[0012] There is provided a take-off and landing method of a fixed-wing unmanned aerial vehicle (UAV) take-off and landing system, where a process of launching the UAV including the steps of:

[0013] step one: adjusting a tilt angle of two adjusting frames relative to the
25 launch rack, adjusting a horizontal distance between two check frames arranged on the adjusting frames, and placing the UAV about to take off on the launch rack;

[0014] step two: driving, by a servomotor, a take-up reel to rotate, so that a primary wiring groove of the take-up reel releases the first rope, after the release is completed, a secondary wiring groove continues to tract the second rope, the second
30 rope is divided into two branches which are respectively wound around wire guiding wheel on the groove frame, the two locking cams are pulled towards the two sides, and thus releasing the catapult;

[0015] step three: pushing, by a compression spring on an outer wall of the catapult to move forward along an inner wall of the outer sleeve, and also driving the adjustable launcher and the UAV to launch forwards together; and

[0016] a process of capturing the UAV including the steps of:

5 [0017] step one: hooking, by a tailhook on the back of UAV, an arresting rope wound in wiring grooves of the leg, to drive the arresting rope to pull the tension sensor and the third rope;

[0018] step two: pulling, by the third rope, the catapult to compress the spring and absorb the kinetic energy of the UAV, where the inertia of moving upwards is

10 generated around the light-weight pulley at the same time of pulling the arresting rope, thus striking the arresting net, and then completing the process of capturing.

[0019] The take-off and landing system is capable of achieving catapult takeoff and smoothly-arrested landing of fixed-wing UAVs with various sizes, and has the advantages of good invisibility, economy and adaptability.

15 [0020] By changing the tilt angle of an adjusting frame relative to a launch rack, a horizontal distance between two check frames of a UAV can be changed, and thus fixed-wing UAVs with various sizes can be catapulted.

[0021] The energy storage device according to the present invention not only can provide a power supply for catapult takeoff of a fixed-wing UAV, but also

20 absorb energy during arresting recovery of the fixed-wing UAV, so that takeoff and recovery systems can be unified into the same system, there is no need to independently arrange two independent facilities, and therefore, rapid catapult takeoff and smoothly-arrested net capturing recovery of a fixed-wing UAV can be achieved, the cost can be reduced, and the utilization rate of the system can be

25 improved.

[0022] Since takeoff and landing space of UAVs can be saved, the present invention is more adaptable to auxiliary takeoff and landing requirements of fixed-wing UAVs in environments, such as ships, mountain areas and deserts.

BRIEF DESCRIPTION OF THE DRAWINGS

30 [0023] FIG. 1 is a stereoscopic view according to the present invention.

[0024] FIG. 2 is a stereoscopic view (from another perspective) according to the

present invention.

[0025] FIG. 3 is an enlarged view of portion A in FIG. 1.

[0026] FIG. 4 is a schematic view with an outer sleeve removed according to the present invention.

5 [0027] FIG. 5 is a schematic view in a catapult takeoff state according to the present invention.

[0028] FIG. 6 is a schematic view in a recovery state according to the present invention.

DETAILED DESCRIPTION

10 [0029] As illustrated in FIG. 1 and FIG. 2, there is provided a fixed-wing unmanned aerial vehicle (UAV) take-off and landing system according to an embodiment, including: a base 1, a front end of which is arranged with an energy storage device via a boss 2, where the energy storage device includes an outer sleeve 3 which is fixedly arranged on an upper surface of the boss 2, a catapult 4, which
15 slides along an outer sleeve 3, is nested within the outer sleeve 3, a front end of the catapult 4 is arranged with an adjustable launcher, where the adjustable launcher includes a launch rack 5 being fixedly arranged on an upper surface of the catapult 4 and in parallel therewith, two sides of which are respectively rotatably connected to adjusting frames 6, inner sides of each adjusting frame 6 are respectively fixedly
20 connected to UAV brackets 7, rear-top sides of each adjusting frame 6 are arranged with check frames 8; a rear end face of the outer sleeve 3 is arranged with a baffle plate 9 with a round hole formed in the middle, a lower side of the baffle plate 9 is connected to a groove frame 10 arranged at the rear end face of the boss 2, the groove frame 10 is provided with a locking mechanism, and the end of the catapult 4
25 penetrates through the round hole of the baffle plate 9 and snaps into the locking mechanism;

[0030] a rear end face of the catapult 4 is connected to a drive control mechanism via a first rope 11, the drive control mechanism includes a take-up reel driven by a servomotor 13 arranged in the middle of an upper surface of the base 1,
30 a primary wiring groove 12 is provided along the circumference of the take-up reel for winding the first rope 11, a secondary wiring groove 14 being concentric with

the primary wiring groove 12 extends axially along an outer end surface of the take-up reel and is wound with the second rope 15, and the other end of the second rope 15 is connected to the locking mechanism; a rear end face of the catapult 4 is connected to an arresting recovery mechanism via a third rope 16, the arresting
5 recovery mechanism includes a tilt support 17 connected to a tail portion of the base 1, a light-weight pulley 33 is arranged at an upper end of the tilt support 17, legs 18 are arranged on both sides of a lower portion of the tilt support 17, an arresting rope 19 is wound on the legs 18 and the light-weight pulley 33, an end of the arresting rope 19 is connected with a tension sensor 20, and the other end of the tension
10 sensor 20 is connected with the third rope 16; an arresting net 21 is hoisted on a bottom surface of the boss 2; a signal transmission and control device is further arranged in the middle of the upper surface of the base 1.

[0031] Each adjusting frame 6 is of a trapezoidal structure, a round rod is arranged at the top of the adjusting frame 6, and the two ends of the lower side of
15 the round rod are connected with the launch rack 5 via two inclined rods respectively, a front end surface of the round rod is fixedly connected to a UAV bracket 7, which is of an L-shaped structure and lies in the same horizontal plane with the round rod, the rear end of the round rod is connected with a check frame 8 via a revolute pair, the check frame 8 is of an L-shaped structure and lies in the same vertical plane with
20 the round rod; and a fixing rod 23 with a chute is jointly connected to the rear end surfaces of the check frame 8 of the two adjusting frames 6.

[0032] As illustrated in FIG. 3, the locking mechanism includes two locking cams 27 arranged oppositely, where, lower ends of the two locking cams 27 are respectively fixed to the groove frame 10 via a revolute pair, middle portions of the
25 two locking cams 27 are connected via a tension spring 28, upper ends of the two locking cams 27 form a ring communicated with the round hole on the baffle plate 9, and an end of the catapult 4 penetrates through the round hole of the baffle plate 9 and snaps into the ring.

[0033] The groove frame 10 is L-shaped and includes a vertical plane and a
30 horizontal plane extending at the bottom, the two locking cams 27 are arranged in the middle of the vertical plane, four corners of the vertical plane are respectively arranged with a wire guiding wheel 29, two wire guiding wheels 29 are arranged on

the horizontal plane at intervals, top ends of the two locking cams 27 are respectively fixed with two joints of the second rope 15 via eyebolts, the two joints are respectively wound around the wire guiding wheel 29 on the vertical plane from both sides, respectively wound around the two wire guiding wheel 29 on the horizontal plane, converged into a single rope through a latch and then wound into the secondary wiring groove 14.

[0034] There are two tilt supports 17, which are fixed to a tail end of the base 1 by a screw connection, a light-weight pulley 33 is arranged at an upper end of the tilt support 17 via a shaft and a thrust bearing sleeve, there are two legs 18, which are in an inverted-V shape and symmetrically arranged below the two tilt supports 17, upper ends of the two legs 18 are respectively connected with the two tilt supports 17 through a hinge structure, bottom ends of the two legs 18 are supported on the ground and provided with wiring grooves, after extending from one end of the tension sensor 20 and winding around the light-weight pulley 33, the arresting rope 19 is split into two strands of wiring grooves winding around the light-weight pulley 33, and an isosceles triangle-shaped wiring net is formed by the arresting rope 19.

[0035] An arresting net 21, which is of elastic mesh surface material, is hoisted on a bottom surface of the boss 2 via a connector 22.

[0036] The radius of the primary wiring groove 12 is larger than the radius of the secondary wiring groove 14.

[0037] The signal transmission and control device includes a servo drive 26 arranged in the middle of the upper surface of the base 1 for controlling rotation of the servomotor 13, an upper computer 24 configured to calculate and transmit dynamic parameters, and a motion control card 25 configured to receive a motion control program from the upper computer 24 and transmit signals to the servo drive 26.

[0038] As illustrated in FIG. 4, the catapult 4 is in a cylindrical shape as a whole, and a plurality of compression springs 30 are axially arranged along the outer wall of the catapult 4, one end of the compression spring 30 is fixed on the outer wall of the catapult 4, and the other end of the compression spring 30 is fixed on the inner wall of the baffle plate 9, a plurality of groove holes for receiving the compression springs 30 are axially arranged in the inner wall surface of the outer sleeve 3; an end

of the catapult 4 extends to form a conical structure and matches with a round hole of the baffle plate 9.

[0039] As illustrated in FIG. 5 and FIG. 6, there is provided a take-off and landing method of a fixed-wing UAV take-off and landing system, where a process of launching the UAV 31 including the steps of:

[0040] step one: adjusting a tilt angle of two adjusting frames 6 relative to the launch rack 5, adjusting a horizontal distance between two check frames 8 on the adjusting frames 6, and placing the UAV 31 about to take off on the launch rack 5;

[0041] step two: driving, by a servomotor 13, a take-up reel to rotate, so that a primary wiring groove 12 of the take-up reel releases the first rope 11, after the release is completed, a secondary wiring groove 14 continues to tract the second rope 15, the second rope 15 is divided into two branches which are respectively wound around wire guiding wheel 29 on the groove frame 10, the two locking cams 27 are pulled towards the two sides, and thus releasing the catapult 4;

[0042] step three: pushing, by a compression spring 30 on an outer wall of the catapult 4 to move forward along an inner wall of the outer sleeve 3, and also driving the adjustable launcher and the UAV 31 to launch forwards together; and

[0043] a process of capturing the UAV 31 including the steps of:

[0044] step one: hooking, by a tailhook 32 on the back of UAV 31, an arresting rope 19 wound in wiring grooves of the leg 18, to drive the arresting rope 19 to pull the tension sensor 20 and the third rope 16;

[0045] step two: pulling, by the third rope 16, the catapult 4 to compress the spring 30 and absorb the kinetic energy of the UAV 31, where the inertia of moving upwards is generated around the light-weight pulley 33 at the same time of pulling the arresting rope 19, thus striking the arresting net 21, and then completing the process of capturing.

[0046] In this embodiment, the drive control mode of the fixed-wing UAV take-off and landing system is as follows:

[0047] Before the arresting rope 19 hooks the tailhook 32 of the UAV, the UAV 31 transmits parameters, such as a speed v , a height h and an equivalent mass M of the UAV to an upper computer 24, via a built-in wireless transmission module, and on the basis of dynamic parameters of the UAV 31, the upper computer 24 calculates

the kinetic energy difference ΔE and the potential energy difference ΔP during landing, and then builds a dynamic model of the fixed-wing UAV arresting system:

$$[0048] \quad \begin{cases} (\ddot{l} - \dot{\theta}^2 l) \cos \theta - (2\dot{l}\dot{\theta} + \ddot{\theta}l) \sin \theta = \frac{3(\Delta E - \Delta P)}{ML^3} l^2 \cos \theta \\ (\ddot{l} - \dot{\theta}^2 l) \sin \theta + (2\dot{l}\dot{\theta} + \ddot{\theta}l) \cos \theta = \frac{3(\Delta E - \Delta P)}{ML^3} l^2 \sin \theta - g \end{cases},$$

[0049] where, l is a displacement variation of the tension sensor after the UAV hooks the arresting rope 19, θ is a base angle of an isosceles triangle-shaped wiring net formed by the arresting rope among the light-weight pulley 33 and the two legs 18, and L is a maximum horizontal displacement of the tension sensor 20; a kinematic equation for arrested landing of the UAV is to be solved:

$$[0050] \quad \begin{cases} l = l(t) \\ \theta = \theta(t) \end{cases},$$

10 [0051] then, according to the kinematic equation, the requiring tension $T(t)$ of the arresting rope and the rotational speed $\omega(t)$ of the servomotor are to be solved:

$$[0052] \quad \begin{cases} T(t) = \frac{3(\Delta E - \Delta P)}{L^3} [l(t)]^2 \\ \omega(t) = R^{-1} \cdot \frac{dl}{dt} + \varphi(t) \end{cases},$$

[0053] where, R is the radius of the primary wiring groove of the take-up reel, and $\varphi(t)$ is an angular displacement compensation function of the servomotor 13.

15 Then, a motion control program is generated automatically according to the rotational speed variation function of the servomotor and downloaded to the motion control card 25, when the arresting rope 19 hooks the tailhook 32 of the UAV, the tension sensor 20 senses the tension in the arresting rope 19, and feedbacks to the motion control card 25, if the tension value exceeds a predefined range, the motion control card 25 starts to execute the motion control program, and transmits pulses to the servo drive 26 so as to drive the servomotor 13, causing the servomotor 13 to drive the take-up reel to rotate, and pull the catapult 14 with the first rope 11 wound on the primary wiring groove 12, thus reducing the tension value of the arresting rope 19 to a predefined range and achieving smoothly-arrested landing of fixed-wing UAV 31.

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CLAIMS

What is claimed is:

1. A fixed-wing unmanned aerial vehicle (UAV) take-off and landing system, characterized by comprising: a base (1), wherein a front end of the base (1) is arranged with an energy storage device via a boss (2), the energy storage device comprises an outer sleeve (3) which is fixedly arranged on an upper surface of the boss (2), a catapult (4), which slides along an outer sleeve (3), is nested within the outer sleeve (3), a front end of the catapult (4) is arranged with an adjustable launcher, wherein the adjustable launcher comprises a launch rack (5), two sides of which are respectively rotatably connected to adjusting frames (6), inner sides of each adjusting frame (6) are respectively fixedly connected to UAV brackets (7), rear-top sides of each adjusting frame (6) are arranged with check frames (8); a rear end face of the outer sleeve (3) is arranged with a baffle plate (9) with a round hole formed in the middle, a lower side of the baffle plate (9) is connected to a groove frame (10) arranged at the rear end face of the boss (2), the groove frame (10) is provided with a locking mechanism, the catapult (4) is connected to the baffle plate (9) via a spring, an end of the catapult (4) penetrates through the round hole of the baffle plate (9) and snaps into the locking mechanism;

a rear end face of the catapult (4) is connected to a drive control mechanism via a first rope (11), the drive control mechanism comprises a take-up reel driven by a servomotor (13) arranged in the middle of an upper surface of the base (1), a primary wiring groove (12) is provided along the circumference of the take-up reel for winding the first rope (11), a secondary wiring groove (14) being concentric with the primary wiring groove (12) extends axially along an outer end surface of the take-up reel and is wound with the second rope (15), and the other end of the second rope (15) is connected to the locking mechanism;

a rear end face of the catapult (4) is connected to an arresting recovery mechanism via a third rope (16), the arresting recovery mechanism comprises tilt supports (17) connected to both sides of a tail end of the base (1), a light-weight pulley (33) is arranged at an upper end of the tilt support (17) via a shaft, legs (18) are arranged on both sides of a lower portion of the tilt support (17), an arresting

rope (19) is wound on the two legs (18) and the light-weight pulley (33) and arranged in a triangular shape, a rear end of the arresting rope (19) is connected to a tension sensor (20), and the other end of the tension sensor (20) is connected to the third rope (16);

5 an arresting net (21) is hoisted on a bottom surface of the boss (2); a signal transmission and control device is arranged in the middle of the upper surface of the base (1), wherein the signal transmission and control device comprises a servo drive (26) arranged in the middle of the upper surface of the base (1) for controlling rotation of the servomotor (13), an upper computer (24) configured to calculate and
10 transmit dynamic parameters, and a motion control card (25) configured to receive a motion control program from the upper computer (24) and transmit signals to the servo drive (26).

2. The fixed-wing UAV take-off and landing system according to claim 1, characterized in that, the locking mechanism comprises two locking cams (27)
15 arranged oppositely, wherein, lower ends of the two locking cams (27) are respectively fixed to the groove frame (10) via a revolute pair, middle portions of the two locking cams (27) are connected via a tension spring (28), upper ends of the two locking cams (27) form a ring communicated with the round hole on the baffle plate (9), and an end of the catapult (4) penetrates through the round hole of the baffle
20 plate (9) and snaps into the ring.

3. The fixed-wing UAV take-off and landing system according to claim 2, characterized in that, the groove frame (10) is L-shaped and comprises a vertical plane and a horizontal plane extending at the bottom, the two locking cams (27) are arranged in the middle of the vertical plane, four corners of the vertical plane are
25 respectively arranged with a wire guiding wheel (29), two wire guiding wheels (29) are arranged on the horizontal plane at intervals, top ends of the two locking cams (27) are respectively fixed with two joints of the second rope (15) via eyebolts, the two joints are respectively wound around the wire guiding wheel (29) on the vertical plane from both sides, respectively wound around the two wire guiding wheel (29)
30 on the horizontal plane, converged into a single rope through a latch and then wound into the secondary wiring groove (14).

4. A take-off and landing method of a fixed-wing UAV take-off and landing

system according to claim 1, characterized in that, a process of launching a UAV (31) comprising the steps of:

5 step one: adjusting a tilt angle of two adjusting frames (6) relative to the launch rack (5), adjusting a horizontal distance between two check frames (8) arranged on the adjusting frames (6), and placing the UAV (31) about to take off on the launch rack (5);

10 step two: driving, by a servomotor (13), a take-up reel to rotate, so that a primary wiring groove (12) of the take-up reel releases the first rope (11), after the release is completed, a secondary wiring groove (14) continues to tract the second rope (15), the second rope (15) is divided into two branches which are respectively wound around wire guiding wheel (29) on the groove frame (10), the two locking cams (27) are pulled towards the two sides, and thus releasing the catapult (4);

15 step three: pushing, by a compression spring (30) on an outer wall of the catapult (4) to move forward along an inner wall of the outer sleeve (3), and also driving the adjustable launcher and the UAV (31) to launch forwards together; and

 a process of capturing the UAV (31) comprising the steps of:

 step one: hooking, by a tailhook (32) on the back of UAV (31), an arresting rope (19) wound in wiring grooves of the leg (18), to drive the arresting rope (19) to pull the tension sensor (20) and the third rope (16);

20 step two: pulling, by the third rope (16), the catapult (4) to compress the spring (30) and absorb the kinetic energy of the UAV (31), wherein the inertia of moving upwards is generated around the light-weight pulley (33) at the same time of pulling the arresting rope (19), thus striking the arresting net (21), and then completing the process of capturing.

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