

A SAFE UNMANNED AERIAL VEHICLE SYSTEM

Field of Invention

- 5 The invention relates to the field of unmanned aerial systems (UAS). Particularly, the invention relates to the field of tethered unmanned aerial systems intended for building inspections, especially for buildings in or near the airports and city centers, where flying of UAS is strictly not allowed or heavily controlled and regulated.

10 Background of Invention

- During the construction process, building inspections are carried out at different stages to ensure the work is of satisfactory quality and performed in accordance with approved plans and specifications as well as industry standards and regulations. Besides, buildings should be
15 inspected regularly to ensure that their structural stability or integrity remains at a level safe for their intended use and occupancy. Building inspection identifies any area in the building that is subject to excessive erosion, corrosion, wear, fatigue, stress or strain. It allows early detection and rectification of structural defects due to age and wear of the building. In addition, during building inspection, the likelihood of partial or complete collapse of a
20 building and the subsequent death or injury to individuals as well as damage to other properties within or outside the building is evaluated. Appropriate measures can be taken to prevent further deterioration and strengthen building structures so that the buildings can continue to be used and occupied safely.

- 25 Building inspection includes visual inspection and full structural investigation. Unmanned aerial vehicles (UAV), or drones, are particularly useful for visual inspection of existing buildings and ongoing construction projects. Drone inspection of construction sites or buildings is more efficient and cost-effective than manual inspection. Drones swiftly cover extensive areas and deliver fast insights, thereby significantly reducing the total time
30 investment needed to inspect large structures. Accordingly, the labor costs for building inspection is significantly reduced. Additionally, drone inspection eliminates the need for risky manual assessments, thereby significantly reducing the incidence of on-site accidents

and enhancing safety standard. Moreover, drones can reach areas that are usually deemed inaccessible or dangerous for building inspectors, and allow seamless assessments with minimal disturbance to users and occupants of the buildings.

- 5 A number of patented technologies related to drone systems for building inspections are available. For instance, a United States Patent No. US11106208B2 disclosed a building quality inspection system having a drone and a robot. The drone is configured to carry out visual inspection of the exterior of the building while the robot is configured to carry out an exterior inspection at the location where damage is suspected based the inspection data
10 collected by the drone. However, traditional drones are powered by internal batteries and thus their flight time may be limited by the capacity of the batteries. A Korea Patent No. KR102231048B1 disclosed a tethered drone system whereby a tethered-drone is supplied with power from the ground instead of internal batteries. Particularly, the tethered-drone system comprises a tension control unit for winding or unwinding a cable connecting the
15 tethered drone and a ground station and a power supply unit for supplying power to the tethered drone and the ground station through the cable. Nevertheless, none of the drone systems disclosed in the abovementioned patent documents provides safety measures to protects the drone in the event of a fall during flight.
- 20 Drones may fall from the sky during flight for various reasons including mechanical faults, poor flying skills, communication errors, lack of obstacle avoidance, etc. Regardless of the size and complexity of the drones, drones falling from the sky can be equally dangerous and cause harm to people and properties. Besides, when the drones fall from sky, they suffer a strong impact and break into pieces, resulting in monetary losses. Therefore, it is critical to
25 provide safety measures to drone systems to protect the users, public, devices and properties from harm and damage.

The present invention provides an unmanned aerial vehicle system with fall protection features that is suitable for use in building inspections.

Summary of Invention

5 An object of the invention is to provide an unmanned aerial vehicle system having safe falling mechanism, wherein the unmanned aerial vehicle system includes a protective cage within which the unmanned aerial vehicle is positioned. The protective cage reduces the impact force of a fall on the unmanned aerial vehicle, user, public and properties. Preferably, the protective cage is made of flexible fiber reinforced plastic material to absorb and dampen shock impulses.

10 Another object of the invention is to provide an unmanned aerial vehicle system having safe falling mechanism, wherein the unmanned aerial vehicle system includes a protective cage having an ejectable parachute and inflatable cushions. Both the ejectable parachute and inflatable cushions are configured to automatically deploy upon detection of free fall of the
15 unmanned aerial vehicle in order to slow down the falling of the unmanned aerial vehicle and dampen shock during impact.

Yet another object of the invention is to provide an unmanned aerial vehicle system having safe falling mechanism, wherein the unmanned aerial vehicle system includes a free fall
20 detection sensor. The free fall detection sensor is configured to automatically trigger deployment of the ejectable parachute and inflatable cushions upon detection of a rapid descent of the unmanned aerial vehicle.

Still another object of the invention is to provide an unmanned aerial vehicle system having
25 a tethered unmanned aerial vehicle. Particularly, the unmanned aerial vehicle operates without a built-in battery and is powered entirely through a tether connected to a base station. In the event of a tether breakage, the power supply to the unmanned aerial vehicle will be cut off, consequently the unmanned aerial vehicle will stop flying and fall towards the ground, thereby facilitating retrieval of the unmanned aerial vehicle.

30 At least one of the preceding objects is met, in whole or in part, in which the embodiment of the present invention describes an unmanned aerial vehicle system comprising an unmanned

aerial vehicle devoid of a built-in battery; a base station comprising a power supply unit for supplying electric power to the unmanned aerial vehicle, a tether configured to connect the unmanned aerial vehicle to the base station, transmit power from the power supply unit to the unmanned aerial vehicle and transmit data signals between the unmanned aerial vehicle and the base station, and a tether winch mechanism for extending and retracting the tether; and a protection cage surrounding the unmanned aerial vehicle, wherein the protection cage comprises an ejectable parachute and a plurality of inflatable cushions which are configured to deploy upon detection of breakage of the tether or free fall of the unmanned aerial vehicle.

10 In a preferred embodiment of the invention, the unmanned aerial vehicle system further comprises a free fall detection sensor, wherein the free fall detection sensor automatically triggers the deployment of the ejectable parachute and the inflatable cushions when a rapid descent is detected.

15 In a preferred embodiment of the invention, the unmanned aerial vehicle system further comprises a remote controller for controlling the operations of the unmanned aerial vehicle.

In a preferred embodiment of the invention, the unmanned aerial vehicle system further comprises an electronic device selected from any one or any combination of an imaging device, a light emitting device, a sound output device, a Wi-Fi signal transmitter and a sensor.

20 In a preferred embodiment of the invention, the unmanned aerial vehicle system further comprises an extendable holder for securing the electronic device on the unmanned aerial vehicle or the protection cage, the extendable holder is configured to extend or retract to move the electronic device relative to the unmanned aerial vehicle or the protection cage.

In a preferred embodiment of the invention, the protection cage is removably attached to the unmanned aerial vehicle via a plurality of connecting members. Preferably, the connecting members are elongate members made from steel, aluminium or fibre glass.

30

In a preferred embodiment of the invention, the unmanned aerial vehicle is positioned in the middle of the protection cage.

In a preferred embodiment of the invention, the base station further comprises a counterweight for the unmanned aerial vehicle.

- 5 In a preferred embodiment of the invention, the power supply unit is a battery, a generator, or a power adapter for deriving power from an external power source.

In a preferred embodiment of the invention, the protection cage has a collapsible lantern structure. Preferably, the protection cage comprises a plurality of ribs arranged in such a manner that the protection cage acquires a collapsible lantern structure. Preferably, the
10 inflatable cushion is removably affixed to the outer surface of each alternating rib of the protection cage.

In a preferred embodiment of the invention, the ribs are made of a flexible plastic material.
15 Preferably, the flexible plastic material is fiber-reinforced plastic.

In a preferred embodiment of the invention, the ejectable parachute is removably affixed to the top of the protection cage.

20 In a preferred embodiment of the invention, the unmanned aerial vehicle system further comprises a thermal sensor, an anti-collision proximity sensor, or the combination thereof, wherein the thermal sensor or the anti-collision proximity sensor automatically set the unmanned aerial vehicle to hover when a close object is detected.

25 In a preferred embodiment of the invention, the unmanned aerial vehicle system further comprises an ultrasonic wind speed and direction sensor, wherein the ultrasonic wind speed and direction sensor automatically triggers the unmanned aerial vehicle to return to the base station (20) when a condition uncondusive to the flight of the unmanned aerial vehicle is detected.

30

Brief Description of Drawings

For the purpose of facilitating an understanding of the invention, there are illustrated in the accompanying drawings the preferred embodiments from an inspection of which when considered in connection with the following description, the invention, its construction and operation and many of its advantages would be readily understood and appreciated.

5

Figure 1 shows a preferred embodiment of the unmanned aerial vehicle system of the present invention.

10

Figure 2 illustrates the working state of the unmanned aerial vehicle system of the present invention, in which the unmanned aerial vehicle operates within a limited flight range defined by the length of the tether.

15

Figure 3 illustrates the deployment of the ejectable parachute and inflatable cushions of the unmanned aerial vehicle system when the unmanned aerial vehicle is in the free-fall state, according to the preferred embodiment of the invention.

Figure 4 illustrates two configurations of the protection cage according to the preferred embodiment of the invention.

20 Detailed Description of Invention

25

Hereinafter, the invention shall be described according to the preferred embodiments of the present invention and by referring to the accompanying description and drawings. However, it is to be understood that limiting the description to the preferred embodiments of the invention is merely to facilitate discussion of the present invention and it is envisioned that those skilled in the art may devise various modifications without departing from the scope of the appended claim.

30

The present invention describes an unmanned aerial vehicle system (UAS) (1) suitable for use in urban building inspection, industrial safety monitoring and power plant surveillance. Particularly, the unmanned aerial vehicle system is configured to operate within a prescribed area of the inspection site and not easily deviate from the prescribed area. This system is

particularly useful when the inspection site is a high-rise building and the unmanned aerial vehicle system is at risk of entering restricted airspace, such as buildings in or near the airports and city centers, where flying of unmanned aerial vehicle is strictly not allowed or heavily controlled and regulated. Furthermore, the unmanned aerial vehicle system is
5 equipped with fall protection mechanism that reduces, if not prevents, damage to the unmanned aerial vehicle from falling and harm to the user and the public.

As shown in Figure 1, the unmanned aerial vehicle system (1) comprises an unmanned aerial vehicle (10), a base station (20), a tether (22) connecting the unmanned aerial vehicle (10) to
10 the base station (20), a protection cage (30) surrounding the unmanned aerial vehicle (10), an ejectable parachute (31) and a plurality of inflatable cushions (32) equipped on the protection cage (30), and connecting members (35) connecting the protection cage (30) to the unmanned aerial vehicle (10). Not shown in the accompanying figures, the unmanned aerial vehicle system (1) disclosed herein may comprise two or more unmanned aerial vehicles (10), each
15 unmanned aerial vehicle (10) being connected to the same base station (20) via separate tether (22).

Pursuant to the preferred embodiment of the invention, the unmanned aerial vehicle (10) is a small flying device devoid of a built-in battery. The terms “unmanned aerial vehicle” and
20 “drone” are used interchangeably herein unless otherwise stated. The unmanned aerial vehicle (10) comprises, but not limited to, a fuselage, a plurality of propellers, a motor, a flight controller, a speed controller, a landing gear, and a navigation system. Preferably, the unmanned aerial vehicle (10) is configured for tethered deployment from a base station (20). A tether (22) is configured to connect the unmanned aerial vehicle (10) to the base station
25 (20). A first set of coupling means may be provided on the unmanned aerial vehicle (10), preferably on the bottom, and one end of the tether (22) to couple the one end of the tether (22) to the unmanned aerial vehicle (10). A second set of coupling means is provided on the base station (20) and the other end of the tether (22) to couple the other end of the tether (22) to the base station (20).

30

In accordance with the preferred embodiment of the invention, the base station (20) is a housing or cabinet that holds the power supply unit (23), tether (22) and tether winch

mechanism (23) therewithin. The base station (20) may further provide a storage space for the unmanned aerial vehicle (10) when it is not activated. Furthermore, the base station (20) also serves as a ground anchor point for the unmanned aerial vehicle (10). In one embodiment of the invention, the base station (20) is detachably secured to the ground, a wall or a vehicle
5 (e.g. car, van, truck, etc). In another embodiment of the invention, the base station (20) contains one or more counterweights for the unmanned aerial vehicle (10) and is placed on the ground or a vehicle, fixed or unfixed.

Preferably, the power supply unit (23) held within the base station (20) powers the operations
10 of the unmanned aerial vehicle (10) and the tether winch mechanism (23). The power supply unit (23) may be a battery or a generator. Optionally, the power supply unit (23) may be a power adapter which can derive electrical energy from an external power source such as an electrical outlet (e.g. a socket) or a vehicle battery. The base station (20) may be removably secured onto a vehicle and electrically connected to the vehicle battery unit via the power
15 adapter to derive electricity therefrom. The base station (20) may also be placed near an electrical outlet (e.g. a socket) and electrically connected to the electrical outlet via the power adapter.

Preferably, the base station (20) is connected to the unmanned aerial vehicle (10) through the
20 tether (22). The tether (22) is a thick electrical cable or a bundle of rope and electrical wire being tied or twisted together. The tether (22) is configured to, during flight of the unmanned aerial vehicle (10), continuously transmits power from the power supply unit (23) to the unmanned aerial vehicle (10) and transmit data signals between the unmanned aerial vehicle (10) and the base station (20). Optionally, the tether extending from the base station (20) is
25 connected first to the protection cage (30) and then to the unmanned aerial vehicle (10) in order to transmit power from the power supply unit (23) to the protection cage (30) and the unmanned aerial vehicle (10) as well as the electrical components attached thereto.

In the preferred embodiment of the invention, the base station (20) comprises a tether winch
30 mechanism (21) for extending and retracting the tether (22). The tether winch mechanism (21) comprises components including, but not limited to, a tether (22), a circular drum that allows the tether to wrap around it, a spool that allows the drum to rotate in circular motion,

a motor that powers the circular motion of the drum, and a gear train that provides pulling power to the winch. Particularly, the tether (22) is configured to be operable with the tether winch mechanism (21) and extendable between the unmanned aerial vehicle (10) and the base station (20). The tether (22) may be configured for retractable storage within the base station (20).

The base station (20) may further comprise a controller that is configured to control the tether winch mechanism (21). Preferably, as illustrated in Figure 2, the tether winch mechanism (21) is configured to extend the tether (22) up to a predetermined length, thereby limiting the flight range of the unmanned aerial vehicle (10) to a predetermined operational area and altitude. The predetermined extendable length can be set by the base station controller. It is preferred that the operation of the tether winch mechanism (21) does not affect the operation and stability of the unmanned aerial vehicle (10). In an exemplary embodiment of the invention, the tether winch mechanism (21) is configured to extend a specified length of the tether (22) based on the data input on the base station controller prior to setting up the unmanned aerial vehicle for operation, and to fully retract the tether (22) after the unmanned aerial vehicle returns to the base station (20). In another exemplary embodiment of the invention, the tether winch mechanism is equipped with a sensor for detecting pull force from the tether (22), wherein the sensor is configured to send a signal to the base station controller upon detection pull of the tether (22). The base station controller is configured to transmit a signal to the unmanned aerial vehicle (10) to cease moving further away relative to the base station (20) in response to the signal of the sensor. It should be understood that, although not described in detail, other operating modules of the tether winch mechanism that do not affect the operation and stability of the unmanned aerial vehicle (10) are also within the scope of the present invention.

Pursuant to the preferred embodiment of the invention, the protection cage (30) holds the unmanned aerial vehicle (10) therewithin to minimize impact force on the unmanned aerial vehicle (10) in the event of a malfunction, particularly during a fall. Preferably, the unmanned aerial vehicle (10) is positioned in the middle of the protection cage (30) to provide relatively balanced protection on all sides of the unmanned aerial vehicle (10). The protection cage (30) is attached to the unmanned aerial vehicle (10) via a plurality of connecting members (35).

Preferably, the connecting members (35) are elongate members made from steel, aluminium or fibre glass. More preferably, the connecting members (35) are selected from steel rods, aluminium rods and fibre glass rods. Any number of connecting members (35) may be used to attach the protection cage (30) to the unmanned aerial vehicle (10) provided the operations
5 of the unmanned aerial vehicle (10) is not impaired.

Figure 1 shows that three connecting members (35) are used to connect the protection cage (30) to the unmanned aerial vehicle (10). The connecting members (35) may be equidistant and/or evenly spaced with equal central angles. The position of the unmanned aerial vehicle
10 (10) relative to the connecting members (35) may or may not change during the flight of the unmanned aerial vehicle (10). Preferably, both ends of the connecting members are provided with coupling members while complementary coupling members are provided on the protection cage (30) and the body of the unmanned aerial vehicle (10) for receiving or to be received by the coupling members on the connecting members. Preferably, the protection
15 cage (30) is detachably attached to the body of the unmanned aerial vehicle (10) without affecting the operations of the unmanned aerial vehicle (10).

It is preferred that the protection cage (30) has a collapsible lantern structure that can be switched between an unfolded state and a folded state. Before the unmanned aerial vehicle
20 (10) begins operation, the protection cage (30) is deployed and attached to the unmanned aerial vehicle (10) with the aids of the connecting members and matching coupling members on the protection cage (30) and the unmanned aerial vehicle (10). When the unmanned aerial vehicle (10) is not working, the protection cage (30) can be detached from the unmanned aerial vehicle (10) and switched to the folded state. Advantageously, the collapsible lantern
25 structure of the protection cage (30) allows for easy transport and storage of the protection cage (30) and the unmanned aerial vehicle (10). The protection cage (30) may be kept in the base station (20) in the folded state along with the unmanned aerial vehicle (10).

Pursuant to the preferred embodiment of the invention, the protection cage (30) comprises a
30 plurality of ribs (34) arranged in such a manner that the protection cage (30) acquires a collapsible lantern structure. Preferably, the plurality of ribs (34) is arranged longitudinally and connected or joined at opposite vertical ends as shown in Figure 1. Alternatively, the

plurality of ribs (34) is arranged transversely and connected or joined at opposite horizontal ends. The plurality of ribs (34) moves about the axis of the common joints, thereby converting the protection cage (30) between the folded and unfolded states. In one exemplary embodiment of the invention, the ribs (34) are in arc-shaped or annular shape and arranged in such a way that gives the collapsible lantern structure a spherical shape, a spheroid shape, an oblate shape, a prolate shape, an oblong shape, or the like. Figure 4 show two exemplary configurations of the protection cage (30). Preferably, the ribs (34) are made of lightweight material to reduce impact of weight on the thrust of the unmanned aerial vehicle (10). More preferably, the ribs (34) are made of flexible plastic material to absorb and dampen shock impulses when the unmanned aerial vehicle (10) held within the protection cage (30) falls during flight. Example of flexible plastic material includes fibre-reinforced plastic (FRP).

In the preferred embodiment of the invention, the protection cage (30) is equipped with fall protection mechanism. The fall protection mechanism comprises an ejectable parachute (31). Preferably, the ejectable parachute (31) is removably affixed to the top of the protection cage (30). Figure 2 shows that the ejectable parachute (31) is provided on the protection cage (30) in the folded state that does not obstruct the operations of the unmanned aerial vehicle (10). As illustrated in Figure 3, the ejectable parachute (31) is configured to automatically eject and deploy when the power supply to the unmanned aerial vehicle (10) is cut off during flight, indicating that the tether breaks and the unmanned aerial vehicle is free falling. A signal transmitter may be provided on the unmanned aerial vehicle (10) and a signal receiver may be provided on the ejectable parachute (31), wherein the signal transmitter is configured to automatically send a signal to the ejectable parachute (31) to deploy when the power supply of the unmanned aerial vehicle (10) is cut off.

Preferably, the fall protection mechanism of the protection cage (30) further comprises a plurality of inflatable cushions (32). The terms “inflatable cushion” and “airbag” refers to a flexible bag that is inflated with air quickly to act as a cushion upon deployment and are used interchangeably herein unless otherwise stated. The inflatable cushions (32) may be provided on selected ribs (34) or on all ribs (34) of the protection cage (30). The inflatable cushion is preferred to cover a substantial portion of the rib. Preferably, one inflatable cushion (32) is affixed to the outer surface of each alternating rib (34) of the protection cage (30). More

preferably, the inflatable cushions (32) are affixed from one end to the other along the alternating ribs (34) to provide sufficient protection to the protection cage (30). Figure 2 shows that the inflatable cushions (32) are arranged in the deflated state that does not obstruct the operations of the unmanned aerial vehicle (10). The inflatable cushions (32) are configured to automatically and quickly inflate when the unmanned aerial vehicle (10) loses power due to a tether breakage during flight, as illustrated in Figure 3. A signal transmitter may be provided on the unmanned aerial vehicle (10) and a signal receiver may be provided on the inflatable cushions (32), wherein the signal transmitter is configured to automatically send a signal to the inflatable cushions (32) to deploy when the power supply of the unmanned aerial vehicle (10) is cut off.

In a preferred embodiment of the invention, the unmanned aerial vehicle system (1) further comprises a free fall detection sensor (33) for detecting free fall. Preferably, the free fall detection sensor (33) is an infrared sensor. The free fall detection sensor (33) can be removably affixed to the body of the unmanned aerial vehicle (10) positioned within the protection cage (30). Alternatively, it can be removably attached to the protection cage (30), such as the inner surface of the protection cage ribs (34). The free fall detection sensor (33) is preferably arranged in a manner that does not interrupt the operations of the unmanned aerial vehicle (10). The free fall detection sensor (33) is configured to automatically trigger the deployment of both the ejectable parachute (31) and the inflatable cushions (32) upon detecting a rapid descent of the unmanned aerial vehicle (10) which is indicative of a potential free fall. A signal transmitter may be provided on the free fall detection sensor (33) and signal receivers may be provided on the ejectable parachute (31) and inflatable cushions (32), wherein the signal transmitter is configured to automatically send a signal to the ejectable parachute (31) and inflatable cushions (32) to deploy when the free fall detection sensor (33) detects a rapid descent of the unmanned aerial vehicle (10).

In addition to free fall detection sensor, the unmanned aerial vehicle system (1) may further comprise one or more additional sensors selected from thermal sensor, chemical sensor, light detection and ranging (LiDAR) sensor, distance sensor, current sensor, inertial measurement units (IMUs), barometric pressure sensor, magnetic sensor, radar sensor, multispectral sensor, hyperspectral sensor, orientation sensor, anti-collision proximity sensor, global positioning

system (GPS) sensor, and ultrasonic wind speed and direction sensor. Preferably, the unmanned aerial vehicle system (1) further comprises at least one thermal sensor (36).

5 In an exemplary embodiment of the invention depicted in Figure 4, a plurality of thermal sensors is equipped on the unmanned aerial vehicle (10), such as one in the center of the fuselage and one near each propeller. Thermal sensors detect the heat releasing from most objects and materials. The data may be transformed into images and videos and transmitted to the base station (20) via the tether (22). Anti-collision proximity sensor(s) may also be provided on the unmanned aerial vehicle (10), wherein the anti-collision proximity sensors
10 work together with the thermal sensors to automatically set the unmanned aerial vehicle (10) to hover when a close object is detected. The provision of thermal sensors and anti-collision proximity sensors is very useful in building inspection applications as these sensors help prevent collision of the unmanned aerial vehicle (10) in structurally complex areas. These sensors also help to prevent the unmanned aerial vehicle from striking the building users and
15 other living species during building inspections.

In another exemplary embodiment of the invention, the unmanned aerial vehicle system (1) further comprises at least one chemical sensor. Chemical sensor is particularly useful in building inspections as it can detect the presence of harmful chemicals in the building as well
20 as possible chemical leaks in the building that are undetected by naked eyes.

In another exemplary embodiment of the invention, the unmanned aerial vehicle system (1) further comprises at least one ultrasonic wind speed and direction sensor that is equipped on the unmanned aerial vehicle (10). The ultrasonic wind speed and direction sensor
25 automatically triggers the unmanned aerial vehicle (10) to return to the base station (20) when a condition uncondusive to the flight of the unmanned aerial vehicle (10) is detected. This setting of the unmanned aerial vehicle (10) prevents unnecessary breakage of the tether (22) due to bad weathers such as unforeseen strong winds or air turbulence.

30 The unmanned aerial vehicle system (1) disclosed herein may further comprise a remote controller (40) for controlling the operations of the unmanned aerial vehicle (10). The remote controller (40) is equipped with a signal transmitter while the unmanned aerial vehicle (10)

is equipped with a signal receiver. When the user input commands on the remote controller (40), the remote controller (40) sends the signals to the unmanned aerial vehicle (10) through the signal transmitter. The unmanned aerial vehicle (10) operates in accordance to the commands when the signal receiver receives the signals.

5

Not shown in the accompanying drawings, the unmanned aerial vehicle system (1) further comprises one or more electronic devices selected from an imaging device, a light emitting device, a sound output device, a Wi-Fi signal transmitter and a sensor. Preferably, the one or more electronic devices are equipped on the unmanned aerial vehicle (10) or the protection cage (30). More preferably, the one or more electronic devices are equipped on the unmanned aerial vehicle (10).

The unmanned aerial vehicle system (1) preferably further comprises an extendable holder for securing the electronic device on the unmanned aerial vehicle (10) or the protection cage (30). The extendable holder is configured to extend or retract to move the electronic device relative to the unmanned aerial vehicle (10) or the protection cage (30). Preferably, the extendable holder is able to extend out from the protection cage (30) so that the electronic device secured on the holder is able to reach areas not accessible by the unmanned aerial vehicle (10), such as underneath railings or within confined spaces. The extendable holder may be extended or retracted manually or remotely. The extendable holder may be a telescopic elongated member that telescopes to move the electronic device relative to the unmanned aerial vehicle (10) or the protection cage (30). Alternatively, the extendable holder may have a foldable elongated member that folds and unfolds to move the electronic device relative to the unmanned aerial vehicle (10) or the protection cage (30).

25

In a preferred embodiment of the invention, the unmanned aerial vehicle (10) is equipped with at least one advanced imaging device capable of capturing and storing still or moving images for visual inspection of a building. More preferably, the unmanned aerial vehicle (10) is equipped with one or more digital cameras with picture taking or video recording capability. The camera(s) may be arranged on the bottom of the unmanned aerial vehicle (10) to provide a wide-angle view, a 180-degree view or a 360-degree view. The camera(s) may be secured onto the body of the unmanned aerial vehicle (10) directly by using fastening means such as

30

screws, bolts, or the like. Alternatively, the camera(s) may be mounted onto the body of the unmanned aerial vehicle (10) indirectly via the extendable holder to inspect hard-to-reach areas. The camera(s) may be configured to continuously take photos and/or videos during the flight of the unmanned aerial vehicle (10). The base station (20) may further comprise a

5 memory to store image data transmitted from the camera through the tether (22).

Claims

1. An unmanned aerial vehicle system (1), comprising:
 - an unmanned aerial vehicle (10) devoid of a built-in battery;
 - 5 a base station (20) comprising:
 - a power supply unit (23) for supplying electric power to the unmanned aerial vehicle (10);
 - a tether (22) configured to connect the unmanned aerial vehicle (10) to the base station (20), transmit power from the power supply unit (23) to the
 - 10 unmanned aerial vehicle (10) and transmit data signals between the unmanned aerial vehicle (10) and the base station (20); and
 - a tether winch mechanism (21) for extending and retracting the tether (22);
 - and
 - a protection cage (30) surrounding the unmanned aerial vehicle (10), the protection
 - 15 cage (30) comprising an ejectable parachute (31) and a plurality of inflatable cushions (32), wherein the ejectable parachute (31) and the inflatable cushions (32) are configured to deploy upon detection of breakage of the tether (22) or free fall of the unmanned aerial vehicle (10).
- 20 2. The unmanned aerial vehicle system (1) according to claim 1, further comprising a free fall detection sensor (33), wherein the free fall detection sensor (33) automatically triggers the deployment of the ejectable parachute (31) and the inflatable cushions (32) when a rapid descent is detected.
- 25 3. The unmanned aerial vehicle system (1) according to claim 1, further comprising a remote controller (40) for controlling the operations of the unmanned aerial vehicle (10).
- 30 4. The unmanned aerial vehicle system (1) according to claim 1, further comprising an electronic device selected from any one or any combination of an imaging device, a light emitting device, a sound output device, a Wi-Fi signal transmitter and a sensor.

5. The unmanned aerial vehicle system according to claim 4, further comprising an extendable holder for securing the electronic device on the unmanned aerial vehicle (10) or the protection cage (30), wherein the extendable holder is configured to extend or retract to move the electronic device relative to the unmanned aerial vehicle (10) or the protection cage (30).
5
6. The unmanned aerial vehicle system (1) according to claim 1, wherein the protection cage (30) is removably attached to the unmanned aerial vehicle (10) via a plurality of connecting members (35).
10
7. The unmanned aerial vehicle system (1) according to claim 6, wherein the connecting members (35) are elongate members made from steel, aluminium or fibre glass.
8. The unmanned aerial vehicle system (1) according to claim 1, wherein the unmanned aerial vehicle (10) is positioned in the middle of the protection cage (30).
15
9. The unmanned aerial vehicle system (1) according to claim 1, wherein the base station (20) further comprises a counterweight for the unmanned aerial vehicle (10).
10. The unmanned aerial vehicle system (1) according to claim 1, wherein the power supply unit (23) is a battery, a generator, or a power adapter for deriving power from an external power source.
20
11. The unmanned aerial vehicle system (1) according to claim 1, wherein the protection cage (30) has a collapsible lantern structure.
25
12. The unmanned aerial vehicle system (1) according to claim 11, wherein the protection cage (30) comprises a plurality of ribs (34) arranged in such a manner that the protection cage (30) acquires a collapsible lantern structure.
30
13. The unmanned aerial vehicle system (1) according to claim 12, wherein the ribs (34) are made of a flexible plastic material.

14. The unmanned aerial vehicle system (1) according to claim 13, wherein the flexible plastic material is fibre-reinforced plastic.
- 5 15. The unmanned aerial vehicle system (1) according to claim 12, wherein the inflatable cushion (32) is removably affixed to the outer surface of each alternating rib (34) of the protection cage (30).
- 10 16. The unmanned aerial vehicle system according to claim 1, wherein the ejectable parachute (31) is removably affixed to the top of the protection cage (30).
- 15 17. The unmanned aerial vehicle system (1) according to claim 1, further comprising a thermal sensor, an anti-collision proximity sensor, or the combination thereof, wherein the thermal sensor or the anti-collision proximity sensor automatically sets the unmanned aerial vehicle (10) to hover when a close object is detected.
- 20 18. The unmanned aerial vehicle system (1) according to claim 1, further comprising an ultrasonic wind speed and direction sensor, wherein the ultrasonic wind speed and direction sensor automatically triggers the unmanned aerial vehicle (10) to return to the base station (20) when a condition unconducive to the flight of the unmanned aerial vehicle (10) is detected.