

Invention Title

A low altitude aircraft identification system

Background of the Invention

- [0001] The related art unmanned aerial vehicles (UAV) or unmanned aircraft system (UAS) markets, which once belonged to professional companies, now has many amateur pilots flying affordable models available in electronic stores and controlled by smartphones. Due to their altitude, speed, and weight, these flying objects can cause damage and injuries. Because of this, a system to manage these vehicles is necessary.
- [0002] Consider the automotive industry: one of the bases of the car control system, like Department of Motor Vehicles (DMV), is the license plate. Analogously, the UAS industry needs an identification system, specifically for small UASs. These aircrafts, weighing up to 25 pounds and flying up to 500 feet of the low altitude airspace, are too small to utilize the large, commercially used, related art tail numbers that other vehicles could use. An identification solution is needed. This solution must allow the vehicle to be identified by people on the ground and by other aircrafts. It must also allow external devices to identify the vehicles in an automated way.
- [0003] The present innovative solution is a system of three components: an identification box attached to the aircrafts (i.e., the "license plate"); a device to be used on the ground to automatically capture the identification code; and a server to store the aircraft data

Brief Summary of the Present Invention

- [0004] The present invention describes an aircraft identification system with three components: an aircraft electronic identification box with an embedded logger; a ground identification device to identify the aircraft by just pointing at it; and a server to store and manage the aircraft information.

Electronic Identification Box

- [0005] A traffic management system must monitor the traffic and notify the responsible party in case of any non-compliance with a regulation. Therefore, to identify the responsible party, the system must identify the vehicle. The ground traffic management system requires all vehicles to have a license plate for driving on public roads. This license plate allows the police and other drivers to identify the vehicle. Similarly, in order to manage the small UASs, it is necessary to have an equivalent structure that functions as a car license plate.
- [0006] Instead of stamping letters and numbers on the aircraft as is done in the related art, the present example implementation is a light array that blinks a unique color pattern sequence for each aircraft. An advantage of this identification mechanism is that a person can visually identify an aircraft from about 500 feet distances without the use of any special equipment. The color sequence can be defined by the pilot, the fleet control, or even by a regulatory agency. The number of colors used and the size of the sequence define the number of possible codes.

- [0007] The light array works together with the electronic identification box. The box has a position logger and a transponder, which may be mobile. The logger has a global positioning system (GPS) module to obtain the absolute position of where the aircraft is flying. The logger stores the flight path of each trip made by the vehicle. The speed and heading are also stored with the positioning information. Telemetry data provided by the aircraft sensors – such as 3-axis acceleration and power level – and application data provided by the autopilot or any embedded component are also stored. This information is the proof of the aircraft real flight data and works as a civil aviation “black box” in case of a crash. In addition, for a UAV doing an autonomous flight beyond line-of-sight, the data shows where the UAS flew. However, the present inventive concept is not limited to the above-enumerated information, and any other data may be added or substituted therefor, without departing from the scope of the example implementations.
- [0008] The transponder transmits a code through the RF frequency similar to the one generated (e.g., blinked) by the light arrays, allowing automatic identification by any RF receiver on land or installed in other aircrafts. In addition to the code, the transponder also transmits the last position, heading and speed, allowing the implementation of a collision avoidance system. The identification box also has an independent battery known by those skilled in the art so the transmitter works even without the external power supply. In case of an aircraft crash, the transponder will keep transmitting the last known position to help to find the wrecked vehicle.
- [0009] The identification box also has a photo sensor to receive external signals. When the photo sensor is excited with a high luminous beam in a specific wavelength (e.g., a laser beam), the identification box can change its operational behavior. For instance, it can change its light brightness, send commands to the autopilot, or increase the data storage frequency, in addition to other options. One of the preset configurations for the photo sensor stimulation is to modify flag data in the RF data sent by the transmitter, and/or to modify the behavior of the blinking pattern. In some scenarios, there will be many aircrafts flying close to each other such that a receiver on the ground would detect all of them without knowing which UAV is transmitting each identification code. Therefore, it is just a matter of directing a specific wavelength light beam emitter to one of the aircrafts and the aircraft will thus modify its behavior and its transmitted data, allowing the data-to-vehicle association. This feature creates a duplex communication, allowing the identification box to send data by its color light emitters and receive data through the light sensor. Commands can also be received and executed using the communication channel. Through a physical connection between the identification box and the UAV autopilot, the identification box can, for instance, receive a way point change command through a modulated light beam and change the UAV destination coordinates.

Ground Identification Device

- [0010] A police department has law enforcement agents who supervise the roads and highways in order to detect drivers disobeying traffic laws. Devices such as radar allow police officers to detect vehicle speeds. Moreover, license plates allow for identifying the vehicle owner and accessing the complete history of the vehicle. This kind of control allows for small remote controlled aircraft surveillance and regulation.
- [0011] In this way, a ground device to assist the aircraft identification has been invented. Since the electronic identification box relies on visual information, the ground device was equipped with a camera and image processing algorithms in order to capture the color sequence. In addition, this device has the RF

receiver capable of receiving the identification box RF signal to cross both information and verify the authenticity.

[0012] The aircraft code and the position where the aircraft was detected are submitted to the central identification server to identify its owner, the responsible pilot and the flight permission. Hence, if the ground user wants to check if one specific vehicle has permission to fly in that area, he just points the identification device to the aircraft. It automatically handles the identification and crosschecks with the central database. After the central system replies, the device shows on the screen if the aircraft position and timestamp is according to its permitted flight plan. In a positive case, the device screen shows a “valid” message. Otherwise, the user will see an “invalid” message. Clicking in the message will reveal the entire information database of the aircraft.

Brief Description of the Several Views of the Drawings

- [0013] FIG 1. Is the external view of the identification box with 4 light arrays.
- [0014] FIG 2. Is the schematic view of the identification box.
- [0015] FIG 3. Is the external view of the ground identification device facing forward and backward.
- [0016] FIG 4. Is the schematic view of the ground identification device.
- [0017] FIG 5. Is the user interface of the ground identification device.
- [0018] FIG 6. Is the server process flow.
- [0019] FIG 7. Is the identification box software flow.
- [0020] FIG 8. Is the ground device software flow.

Reference Numerals in the Drawings

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|--------|-----------------------------------|---------------------------------|
| [0021] | 1 – Identification box | 2 – Light arrays |
| | 3 – Light emitters | 4 – Light sensor |
| | 5 – RF antenna | 6 – Location system antenna |
| | 7 – Memory card slot | 8 – Power connector |
| | 9 – Housing | 10 – Autopilot data connector |
| [0022] | 11 – Light emitter | 12 – RF antenna |
| | 13 – Location system antenna | 14 – Location module |
| | 15 – Non-volatile storage module | 16 – RF module |
| | 17 – Light controller module | 18 – Central control module |
| | 19 – Light receiver | 20 – Internal power storage |
| [0023] | 21 – Ground identification device | 22 – Camera with zoom |
| | 23 – Light beam emitter | 24 – Touchscreen |
| | 25 – General buttons | 26 – RF antenna |
| | 27 – Location system antenna | 28 – Data communication antenna |
| | 29 – Housing | 30 – Data connector |

[0024]	31 – Light beam emitter	32 – Camera module
	33 – RF antenna	34 – Data communication antenna
	35 – Light beam modulator	36 – Image processing module
	37 – RF module	38 – Data communication module
	39 – Central processing unit	40 – Location system antenna
	41 – Location module	
[0025]	51 – ID captured by the camera	52 – Aircraft responsible name
	53 – System message	54 – Detection window
	55 – RF detected IDs	56 – General buttons
[0026]	61 – Aircraft data request flow	62 – Aircraft route confirmation process
	63 – Aircraft destination confirmation process	
[0027]	71 – Main loop flow	72 – Light beam detection flow
	73 – Light beam command execution flow	
[0028]	81 – Identification procedure flow	82 – Light beam excitation flow
	83 – Light beam command transmit flow	

Detailed Description of the Invention

- [0029] FIG. 1 shows the perspective view of one of the two components of the example implementation; FIG. 2 shows its schematic with the internal components; FIG. 7 shows firmware execution flow. The identification box 1 includes light arrays 2 composed of several light color emitters 3. These color emitters 3 are controlled by the light controller module 17, and they generate (e.g., blink, variable light intensity or color fade, or other similar operation as would be understood by those skilled in the art) a defined color sequence programmed in the unit firmware executed by the central control unit 18 and following the main loop flow 71. The identification box 1 also has a radio antenna 5 connected to a RF module 16 that transmits the same code or a modified version of the code through radio signal. The RF module 16 also can receive RF signals from nearby identification boxes installed in other aircrafts and save this information in the non-volatile storage module 15 that is connected to the memory card installed in the memory card slot 7. The example implementation also has one light detection sensor 4 connected to a light receiver module 19 capable detecting external excitation by a light beam with defined wavelength and intensity. In case of external light detection by the light sensor 4, the light beam detection flow 72 is executed. Consequently, the behavior of the identification box can change. For instance, it can add or change extra data information to the transmitted RF signal, or change the light blink pattern or intensity. Besides the identification part, the identification box 1 also has a location system antenna 6 (e.g. GPS antenna) connected to a location module 14 to log the flight path in the storage module 15. This positioning data (e.g. GPS data, camera motion capture, radio triangulation system, or the like) is also transmitted by the RF module 16 with the identification code.
- [0030] The identification box 1 has also an external power connector 8 used to recharge the internal power storage 20 (e.g., Li-Po battery or super capacitor) and supply power to all internal and external

- [0031] components. In case no power is supplied, the internal power storage 20 can supply power to all the components. In this “no external power” state, the RF module 16 will keep following the main loop flow 71, transmitting the last location position and the identification code until the battery runs out of power, while the other components will be in a sleep mode. All of the internal components are protected by a housing 9 against impact and weather, in order to resist a crash without damaging the internal circuit.
- [0032] The other component of the example implementation is the ground identification device 21 seen in perspective in FIG. 3 and its internal schematic in FIG. 4. In addition, the main user interface is shown in FIG. 5, the server process in FIG. 6 and its firmware process flow in FIG 8. The ground identification device 21 has a camera with zoom 22 capable of capturing video in real-time. The identification procedure flow 81 is executed to process the video and identify the aircraft. This video is provided to an image processing module 36 that analyzes the image to detect that the identification box blinks and capture the blink sequence. In case of a successful detection, the detected code is displayed in the touchscreen 24 in the field 51. A detection window 54 will be shown around the detected aircraft. A request to a server will be made to get more aircraft data, following the aircraft request data flow 61. Other information, such as the aircraft owner is presented in the field 52. A location system antenna 27 (e.g., GPS antenna) is connected to a location module 41 in order to get the position where the aircraft was detected. Both information, the detected ID and the location detection position, are transmitted to a server through a data communication antenna 28 connected to a data communication module 38 (e.g. cellular network or Wi-Fi). The server will follow the aircraft route confirmation process 62 and reply with an ID verification message that is presented in the field 53 of the touchscreen 24.
- [0033] The ground identification device 21 also can detect aircrafts through the RF signal transmitted by the identification box RF module 16. The signal is received by the RF receiver antenna 26 connected to the RF receiver module 37. Since many signals can be received at the substantially same time by the receiver module 37, the detected IDs are presented in the field 55 in a list format. If at any time the users decide to use the touchscreen 24 to click on any ID number, a request will be made to a server following the aircraft information flow 61 to show more information about that aircraft.
- [0034] In order to excite the identification box light sensor 19, the ground device has a light beam emitter 23 connected to a light beam modulator 35. The light beam excitation flow 82 is executed by the ground device 21. This beam, when captured by the light sensor 19 will change the data transmitted by the identification box RF module 16. This difference in the data is detected by the ground device RF module 37, and the light excited aircraft ID presented in the field 55 will be shown in a distinguishable form (e.g., bolded).
- [0035] The ground device internal components are protected by a weather proof housing 29. The front screen panel has few general-purpose buttons 25 that can be configured, for instance, to activate the light beam.
- [0036] The identification box light emitters 3 and light sensor 4 create a two-way communication system. Similarly, the ground device camera 22 and light beam emitter 23 also create the same kind of communication. The RF receiver and transmitter 16 and 37 in both devices also creates a duplex communication. Therefore, the identification box 1 and ground device 21 together can exchange information through light or RF. This feature allow other applications. An example application is to send data to a UAV through light and RF. For instance, a delivery drone can receive a message to update its

destination coordinate when it get closer to the delivery address as described following. The ground device 21 detects the UAV flying at a long distance from the user address through the RF signal received by the RF module 37. The ground device 21 communicates with the server sending the received ID and the device location measured by the location module 41 (e.g., GPS, AGPS, Wi-Fi mapping or cellphone tower position) to check if the received ID belongs to a delivery UAV going to the ground device position. The server follows the aircraft destination process flow 63 in order to return the confirmation to the ground device 21. When the server confirms if the UAV is going to the ground device position, the ground device 21 shows on its screen 24 a message informing the user that his delivery is arriving. The user goes outside, points the ground device 21 to the UAV, and uses one of the general-propose buttons 25 to turn on the light emitter 23. At this moment, the ground device 21 will start to transmit its position through the RF module 37. The light sensor 4 of the identification box 1 detects the light beam and the RF module 16 receives the ground device 21 position. The identification box central control module 18 sends destination updates to the UAV autopilot through the autopilot connector 10. After that, the UAV will update its destination to drop the delivery in the exact location the user is transmitting.

[0037] In addition, other applications can be explored if the ground device 21 is attached to an aircraft, and the identification box 1 is attached to a ground object. For instance, an automated landing procedure in a mobile landing pad attached to a vehicle can use these devices in this configuration. The identification device 1 is attached to several landing pads, each one sending a unique identification code through the light emitters 2 and the RF module 16 simultaneously. The aircraft with the ground device 21 pointing to the ground receives the landing pad ID and the location data through the RF module 37. A connection between the aircraft autopilot and the ground device 21 through the data connector 30 allows the ground device to send messages to the aircraft (e.g., destination coordinates update). After receiving the landing pad ID, the ground device 21 searches for the landing pad visual position of that specific landing pad color sequence using the camera 22. This allows a fine control of the aircraft using real-time optical navigation to approach and land in the moving landing pad. This application can be executed in an outdoor and indoor environment, even without the location data been transmitted by the landing pad identification box.

[0038] Finally, the ground device 21 can modulate data through the light beam modulator 35. The identification box central control module 18 can demodulate the light beam in order to execute commands. The light beam command transmit flow 83 is executed by the ground device 21. The user selects the command on the screen 24, and the light beam modulator 35 turns the light beam emitter 23 on and off in a defined frequency and protocol. The identification box light sensor 4 detects the modulated light beam and sends the binary data to the central control unit 18 that executes the light beam command execution flow 73. After the command execution, the identification box 1 sends the execution results (e.g. an ACK, or an error status code) to the ground identification unit 21 through the RF module 16 and it can also change the color sequence to show the result visually. For instance, the light controller module 17 can turn the red color on for a while in case of an invalid command, and the green light in case of a successfully executed command.

Improvements on Related Art

- [0039] The related art aircraft identification systems focus on civil or military aviation. None of the related art systems work for a small aircraft in a low altitude. Using a visible light sequence, any person can visually identify an aircraft in a low altitude flight.
- [0040] The other related art identification systems for aircraft need a radar system or special devices to be able to receive the identification signal, which works well for a scenario involving an airport tower and an aircraft, but does not work for a scenario involving a person and an aircraft.
- [0041] Using visible light identification, a person can observe an aircraft and memorize its color sequence. This approach is similar to the way cars are identifiable by their license plates, instead of the way aircrafts are identified in the related art.

Other Uses or Applications for This Invention

- [0042] This invention is an identification system that can be used to identify any vehicle, ship, aircraft, or other static or mobile objects that is located up to about one mile from an identifier such as a person or other object.

Claims

1. A device that transmit an identification (ID) code using visible light sequence.
2. The device of claim 1, where the color sequence consists of a sequence of different colors in loop.
3. The device of claim 1, where the color sequence consists of just one color with different blink times.
4. The device of claim 1, with other light emitters like LEDs, OLEDs, quantum dots, light bulbs, laser beams, and others.
5. The device of claim 1, where the ID is transmitted by radio frequency (RF).
6. A device that automatically captures the visible code transmitted by the device of claim 1.
7. The device of claim 6, where the code is received by the RF signal that the device of claim 5 transmits.
8. The system comprising the device of claim 1 and the device of claim 6.
9. The system comprising the device of claim 5 and the device of claim 7.
10. The device of claim 1, with an external light detection sensor.
11. The device of claim 5, where the location data is transmitted together with the ID.
12. The device of claim 11, where extra data is transmitted together with the ID.
13. The method of detecting a defined wavelength and intensity light beam to change the extra data transmitted by device of claim 12.
14. The method of detection by the device of claim 7 when the device of claim 10 detects the defined light beam.
15. The device of claim 7, with a defined light beam emitter.
16. The device of claim 7, with a location receiver.
17. The device of claim 7, with a GPS receiver.

18. The device of claim 7, with a cellular network modem.
19. The device of claim 7, with a wireless radio data link.

Abstract

The present invention describes a low altitude aircraft identification system composed by two components: a small aircraft electronic identification box with an embedded logger, and a ground identification equipment to automatically identify the aircraft just pointing at it.

The identification code can be transmitted by a visible light color sequence or by a radio frequency signal. The ground identification device is capable of recognizing both kinds of code.

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