International Journal of Computer Trends and Technology
ISSN: 2231-2803 / https://doi.org/10.14445/22312803/IJCTT-V67I3P104
Volume 67 Issue 3, 13-18, March 2019

Original Article

Black Box Logging System for Drones

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Abstract *- Uncrewed aerial vehicles (UAVs) like drones are in dire need of efficient data retrieval and regular updates. This project aims to create a software use of a fully autonomous system for the effective functioning of drones, either implicitly or partially independent of human control. The implementation is done by providing access only to any one of two designated aviation controllers who is given an irreplaceable token by the Administrator at a time using an asymmetric cryptographic algorithm-RSA Algorithm. This algorithm ensures the avoidance of vulnerability to the drone system. The proposed research architecture aims to provide the recovery mechanism for the obstacles encountered by the drones in real-time scenarios and momentary payload information. This approach will be further evolved based on adaptive learning software (SCENGEN) to facilitate the drones with appropriate solutions for wisely dealing with the security attacks such as repudiation and masquerade during its fly time. The drone's momentary payload information is gathered concerning three scenarios: Target Reached, Midway Hurdle encountered, and Hacking of drone control is finally embedded in the Black Box cloud.*

Keywords *- Unmanned Aerial Vehicles (UAVs), Adaptive Learning, Artificial Intelligence Cryptography, network security, Deep Learning, Database, and Cloud computing.*

I. INTRODUCTION

The multifarious drones are differentiated in their autonomy, the maximum flight duration, and security. These specifications play a vital role in determining the efficiency and efficacy of drones. Drones also include a vivid type of payloads (Camera, Sensor, GPS location, flight controls, freight, etc.) which reckon the whereabouts and factors lead to an expected and good performance measure. There is a need for communication between the drone(s) and its aviation controller through fixed signal strength to avoid interference prompted by any unwanted glitches. Existing studies attribute to determining the flight distance of drones by using trajectory motions, and sensor locations, among others.

1. Levels of Autonomy

The meaningful distinction in the levels of autonomy concerns unmanned systems are automatic and autonomous systems. Automatic systems are fully pre-programmed systems that can perform a pre-programmed assignment independently. Automation also includes flight stabilization. Autonomous systems can deal with unexpected situations by using a pre-programmed rule-set to help them make appropriate decisions. A higher level of autonomy is a human delegated system that can perform many functions independent of human control, i.e., it can perform tasks when delegated to do so. The next level of autonomy is a human-supervised system that can perform various tasks when given certain permissions and directions by a human. The final level of autonomy is a fully autonomous system that receives commands input by a human and translates them into specific tasks without further human interruption [1].

2. Types of Payloads and their Utility

The most important category of payloads in UAVs is sensors. This sensor is being used in the drones of present security techniques equipped with cameras and microphones. Such cameras may enable night vision and heat sensing. Other sensors include location sensors – it is to locate the current location of the drones; biological sensors – trace microorganisms; chemical sensors – also called sniffers, which measure chemical compositions and trace particular chemical substances such as radioactive substances and meteorological sensors that can measure wind, temperature, humidity, etc. [1].

These cameras are used for criminal investigation, military, freight, live surveillance, inspection and maintenance of infrastructure, cinematography, science, infotainment, and archaeology. Law enforcement applications are not restricted to the use of cameras. For instance, heat sensors may be useful for detecting influx to other countries. In the security domain, drones are useful as an observation as well as surveillance instruments which are distinguished by three mechanisms: non-active systems, in which cameras work as a visual deterrent by using fake cameras to create the illusion of surveillance without monitoring or storage;

reactive systems, which have the recording, storage and playback facilities for an event related to fatal incidents; proactive systems with live surveillance from a dedicated control room with recording, storage and playback facilities allowing, for an immediate response to incidence as they occur[1].

The paper is stratified as follows: Section II describes the Literature Review of the Existing System. Section III presents the Proposed System. Section IV presents the experimental results of the drones.

II. LITERATURE REVIEW

In the Existing System, the drones are operated automatically, and it has been controlled by either a non-active system or a reactive system. The frequency spectrum is provided nationally and facilitated by Licence Free Spectrums.

The flight characteristics and the payloads depend on the Level of Autonomy of the drones. The drones can only be controlled at a minimum calculated distance. As the momentary data from the payload of the drones are unable to access by the aviation controller, the cause of the drone's damage is unknown. The level of autonomy has not increased to a higher level. i.e., no drones in the last 2 decades have used a human delegated system or beyond.

Drones are often seen as remote-control aircraft, but some technologies enable autonomous operations, in which the remote control by a human operator is partially or completely excluded. Most drones that are commercially available are remotely controlled, but at the same time, they already contain elements of autonomy, mostly software for flight stabilization. More professional drones offer the possibility to pre-program flights. Shortly, more autonomy is expected concerning determining flight routes, sense and avoid systems for performing evasive maneuvers (e.g., birds, airplanes), adapting to changing weather conditions, and defensive reactions when drones are under attack [1].

ScenGen extends a human's ability to think of all possibilities for any given situation by over tenfold. ScenGen has broad applicability, which is most commonly used to exhaustively "think of" and then "execute" all user actions or systems messages. This technology has been proven to work successfully in most environments to eliminate issues with new releases that would otherwise cause damage, downtime, or misinformation, such as memory exceptions, memory leaks, crashes, and failed installations. Adaptive Learning - ScenGen Software for achieving a fully autonomous drone with less complex sensors and low computational and processing power for adaptive obstacle detection in real-world environments and collecting data from the damaged drones. [2],[4].

A drone communicates directly with one or a few rendezvous nodes because it is impossible to communicate directly with all sensor nodes. Earlier schemes only focus on the drone's energy and flight distance with pre-acquisition information. A new rendezvous point estimation scheme is proposed, which considers the drone's speed and direction and the data collection delay of the entire network without any pre-acquisition information. We designed the rendezvous node selection steps with the new approach and verified the performance of the proposed scheme through a simulation. The simulation results show that our scheme is more reliable than other schemes in terms of the drone speed and data collection delay [3].

There are diverse sorts of drone services that can be executed in various situations. For instance, a drone can act as a security monitor to ensure the safety of somebody strolling home alone in the evening time or a drone can act as a flying camera that can be leased basically by calling the drone to go to a particular area to take photographs or to record videos. Another scenario is a drone that can be used to deliver computing services [5].

Deep learning is a fast-growing domain of machine learning, mainly for solving problems in computer vision. It is a class of machine learning algorithms that use a cascade of many layers of nonlinear processing. It is also part of the broader machine learning field of learning representations of data facilitating end-to-end optimization. Deep learning can learn multiple levels of representations that correspond to hierarchies of concept abstraction [6].

Numerous commercial interests are developing UTM instrumentation for compliant and non-compliant drone detection and countermeasures, but performance in terms of the ability to detect, track, classify(bird, bug, drone, general aviation), identify, and localize aerial objects has not been standardized or well developed to compare multi-sensor solutions [7].

Passive methods are attractive in simplicity, reliability, low cost, and require no additional power. Drones can fly automatically and are controlled at certain elevations and are usually equipped with sensors or cameras to detect and playback record objects underneath. It is an easy-to-learn way of operation that makes many people use drones in different fields. The use of drones can now be used to support daily living needs, such as the use drones for military security, interpersonal services, research or field exploration, watering or spraying plant pesticides, using drones to take pictures of an area, and much more [8],[9].

The high-level modules in this architecture are: (i) the user interface; (ii) the ground station comprising mission control, mission planning, and sensor data analysis; i.e., coordination; (iii) a communication

infrastructure; and (iv) the UAVs with their on-board processing and sensing capabilities. (Fig.2) [10].

III. PROPOSED SYSTEM

The main intention is to emasculate the vulnerability overtly to not hack the drones with the active help of a Higher Level of Autonomy (Fully Autonomous Systems) for the effective functioning of drones either implicitly or partially independent of human control. The accessibility to Fully Autonomous Systems is, in a sense, given only to one aviation controller authenticated by the Administrator through an irreplaceable RSA Token at a time (Fig.1). In addition, a unique Software Program is used to generate all possible scenarios for any given situation at a very high speed (ScenGen). The said software is predominantly used for recovering the payload information of the drones gathered instantly during any snags or aberration embedded in the Black Box Cloud. This uses Regression testing to avoid deadlocks and external mishaps. The system architecture is appended in Fig.2.

A. User Authentication

User Authentication (see Fig.1) is a plug-in that collects user information such as a user ID and password and compares the information against a database entry. Only if the aviation controller is bona fide with valid data is he granted permission to go ahead with the controlling of the drones.

The User Authentication is classified into 3 (three) sessions, viz.

1. Authenticated user verification.
2. RSA Token generation.
3. User Accessibility through the generated RSA token.

The general details of the sessions as mentioned above are illustrated as the Administrator authorizes only two aviation controllers with the RSA token to control the drones, which are implemented by using an Asymmetric key cryptographic algorithm-**RSA Algorithm**. If the member who tries to get control over the drone is not the assigned member, then they may be routed to the login page and start again. If the Administrator authorizes the member, they are given the RSA token, lasting only 12-15 seconds. Suppose the member is unable to log in within the session time. In that case, he is provided with another RSA token, with is also updated in the Local Database of the Administrator.

In particular, for network security purposes, the **RSA Algorithm** can be mentioned vividly as follows:

1. A random 8-digit token is generated as a password for the designated aviation controller one at a time, which lasts for only 12 seconds, ensuring the avoidance of timing attacks of **the RSA Algorithm**.

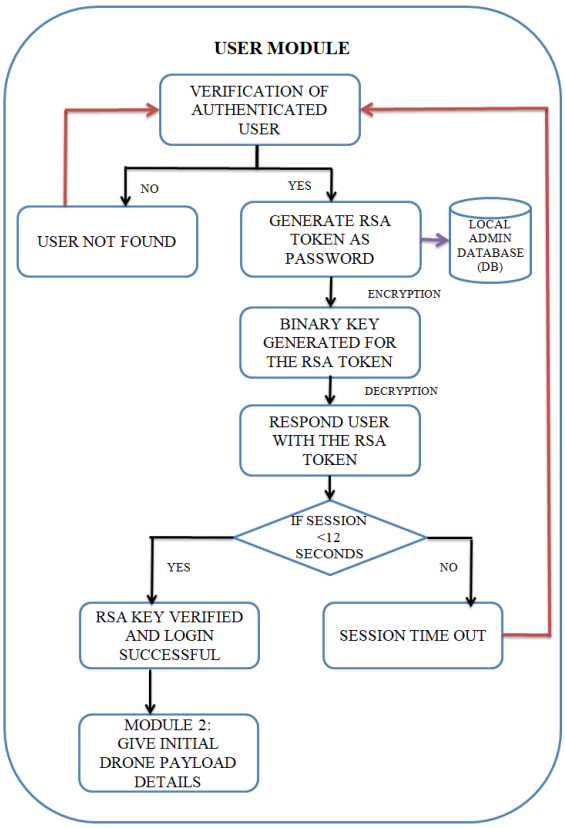


Fig. 1 Workflow of User Authentication

2. In the first instance, this 8-digit token is encrypted using the public key of the aviation controller sent to the Administrator to get hold of a random 8-bit binary key.
3. Secondly, the aviation controller receives the encrypted key and decrypts it using his private key and logs to activate the drones.
4. This RSA Token is unique and irreplaceable to both aviation controllers.

B. Initial Drone Activation Details

Initial Drone Activation Details include the following specifications:

I. SOURCE
   1. Name of the drone.
   2. Purpose of launch.
   3. Location of launch in latitude and longitude.

II. DESTINATION
   1. Location of a target in latitude and longitude.

III. VERTICAL SPEED (VS).

IV. HORIZONTAL SPEED (HS).

The aviation controller manually gives the Initial Drone Activation Details to launch the drones. Horizontal and Vertical Speed is given to avoid initial turbulence due to imbalance or human error.

C. *Private Database Initial Payload Information*

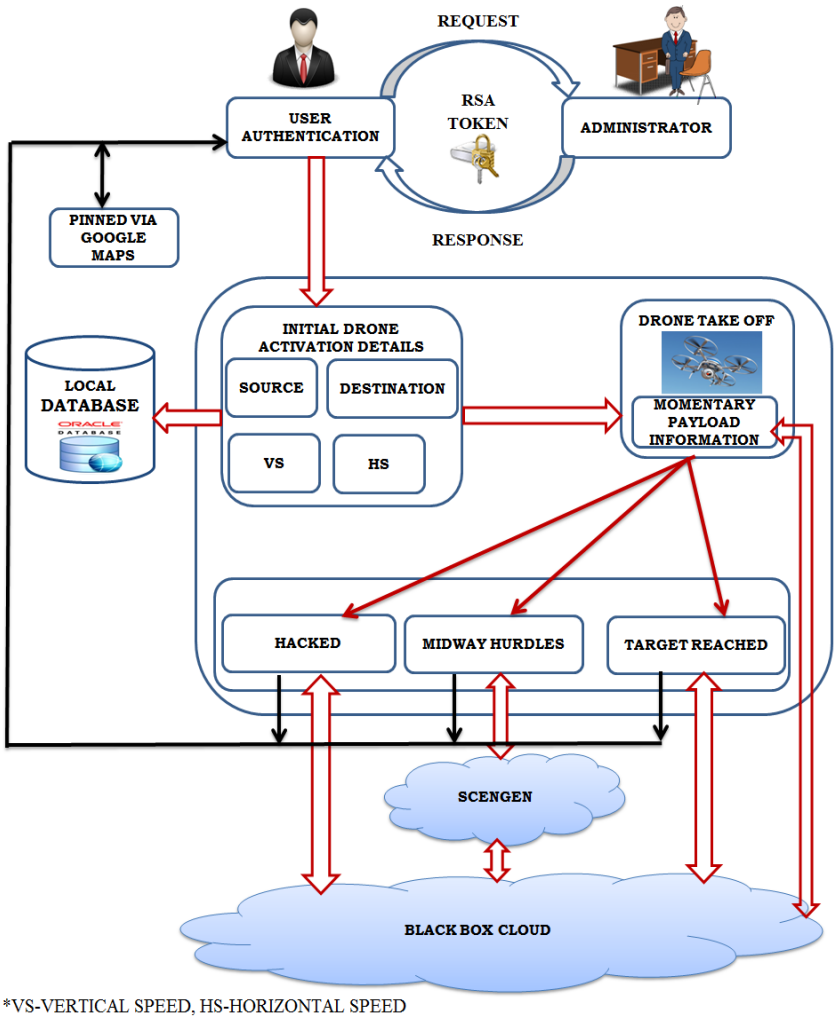
The drone's payload information is stored in the private database of the aviation controller and the Black Box cloud. This is done to identify drones' source, destination, and purpose (criminal investigation, military, freight, live surveillance, inspection and maintenance of infrastructure, cinematography, science, infotainment, and archaeology.)

D. *Black Box Cloud*

The Black Box Cloud consists of the momentary payload information of the drones, which is obtained from communicating with the drone's payload and the type of destruction encountered en route to its target. The Adaptive Learning-ScenGen software solves the unexpected situation that the drones may expect. ScenGen extends a human's ability to think of all possibilities for any given situation by over tenfold. ScenGen has broad applicability, which is most commonly used to exhaustively "think of" and then "execute" all user actions or systems messages. This technology has been proven to work successfully in most environments to eliminate issues with new releases that would otherwise cause damage, downtime, or misinformation, such as memory exceptions, memory leaks, crashes, and failed installations [2]. ScenGen contains the possible ways a drone can get damaged, such as Weather condition, Bird strike, Crash landing, Sniper shot, Stone throw, Hacking, and Improper signal using advanced AI in Adaptive Learning and providing the best solution for these damages caused to the drones. The Black Box cloud also consists of the path the drones travel to reach the stipulated target.

E. *Last Sync Location Retrieval*

The last sync location is retrieved from the Black Box Cloud and pinned via a Google Map with the cause of drone destruction en route to the target.



*VS-VERTICAL SPEED, HS-HORIZONTAL SPEED

Fig. 2 Workflow of the Proposed System

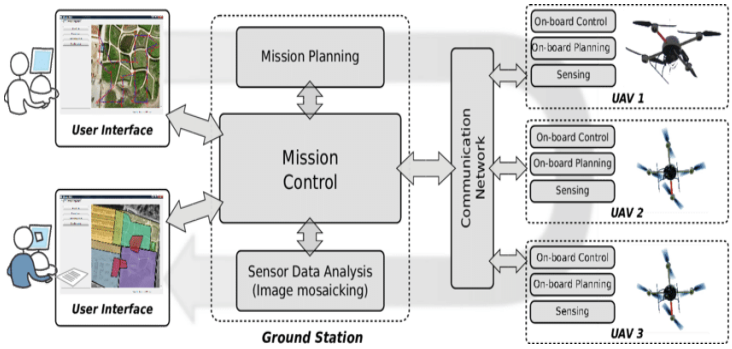


Fig.3 Drone Network Architecture [10]

IV. EXPERIMENTAL RESULTS

The software is programmed as a fully autonomous system based on Java and a basic processor i5 hardware requirement to fly the drone with high throughput. It uses a MySQL server to store the necessary information about the drones for the Administrator. The aviation controller and CloudMe are used to store the momentary data of the drones with reasons for the damages caused en route to the target. The last sync location is depicted via a Google Map indicating the source and destination and also has the location where the drone has encountered an obstacle.

The performance analyses comparing the Proposed and Existing Drone systems are represented as follows:

Fig.4 Performance Analyses of the Proposed and Existing Drone System.

Fig.5.1, 5.2, and 5.3 results show the last sync location of the drones safely reaching the target.

Fig.6.1, 6.2, 6.3 results show the last sync location of the drones damaged before reaching the target.

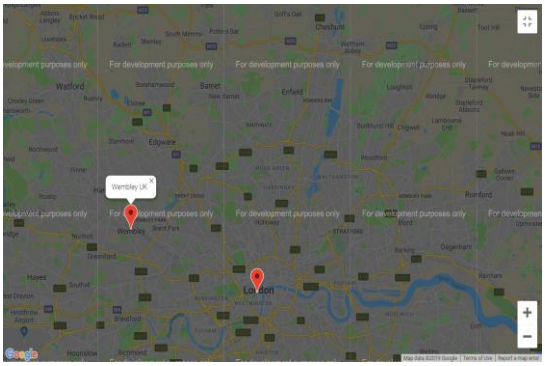


Fig. 5.1 Last Sync Location of the drone safely reaching the target.

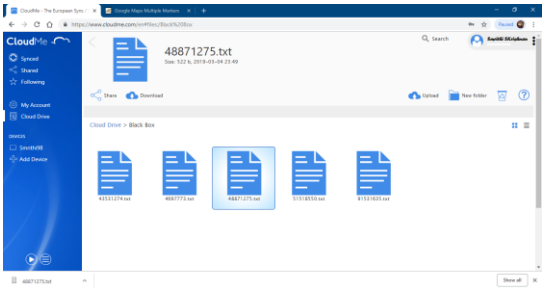


Fig. 5.2 Black Box cloud has the momentary details file.

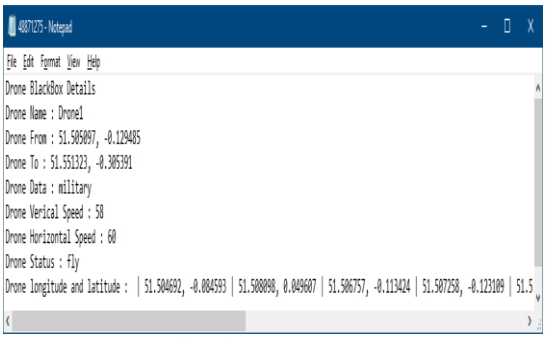


Fig. 5.3 Contents of the file containing the drone's momentary details and status.

Fig. 6.1 Last Sync Location of the drone damaged by Birds Strike before reaching the target.

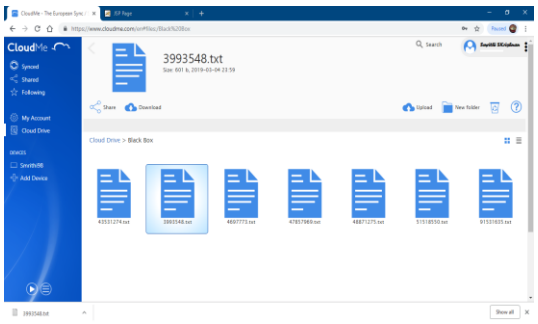


Fig. 6.2 Black Box cloud has the momentary details file.

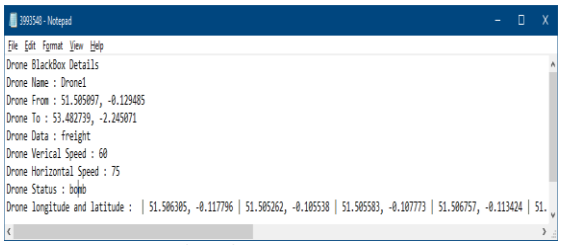


Fig. 6.3 Contents of the file containing the drone's momentary details and status.

V. CONCLUSION

This paper presents the creation of software for the Black Box Logging System in Drones to efficiently retrieve the drone's momentary details without losing payload information.

The Adaptive Learning Software enables a user to operate drones by a fully autonomous system more efficiently for the common good in various areas of applications such as:

1. Military
2. Criminal Investigation
3. Live Surveillance
4. Aerial Photography
5. Inspection and Maintenance of Construction Infrastructure
6. Cinematography, Television, and Infotainment
7. Science and Education
8. Archeology
9. Goods Freight
10. Agriculture

Further development in drone technology can concern swarms embedded with Black Box System for momentary data retrieval, and drone recovery is only possible when those drones are capable of rebounding back to their trajectory path.

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