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Intelligence Gathering Modelling via Unmanned Aerial Vehicle

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ABSTRACT

Unmanned aerial vehicle- (UAV) guided with path planning algorithms can effectively monitor, gather and record intelligent data needed for intelligence gathering. In this work, an advanced and smart type of UAV that is embedded with sensors, wireless links and was considered for deployment, to provide intelligent surveillance for tackling security challenges. To achieve this, a region of interest was chosen and mapped using Google earth pro and quantum geographic information system- (QGIS) software. A model was formulated to determine the number of the ground control station needed for the task. In the same light, a flight path planning algorithm was designed for the UAV trajectory using the pure pursuit and carrot-chasing controllers. The simulation results show that the mapped region was optimally covered by the UAV using the proposed method.

Key words: Path-Planning, Unmanned Aerial Vehicle, Internet of Things, Artificial Intelligence

1. INTRODUCTION

Intelligence is the information harnessed from deliberate search, collection, assessment, unbiased analysis and an eventual summing up and making out a reliable sense from data available to the user. Intelligence gathering (security intelligence) is very crucial for the survival of the territorial integrity of any serious government because it helps converge detailed knowledge of threats and other sensitive security issues that could befall a nation.Hence gathering and sifting through necessary intelligent data is always one of the top priority items on the list of many nations, as such practice constitute and shapes the processes and policies geared towards the protection of citizens and sovereignty ofthat nation.

Nigeria as a nation has recorded losses in both economic and social sense, as a result of attacks from the killer herdsmen who come in the wee hours of the night to unleash terror on the indigenous people [1]. Benue state Nigeria in the recent times has gone from food basket of nation to state prone to continuous, undeterred and calculated invasion from killer herdsmen, who invade with impunity and slaughter at will, leaving anguish, sorrow and amputated spirit behind. The government of Nigeria have used curfews, military check point and operations like the “operation whirl stroke” to handle the situation of information gathering, but being that most of these operations are reactive and proactive, they have not yielded the expected result as reported cases of attacks has been on the rise. Hence this research work geared to proffer a better strategy that will work to curb the violent activities of these herders by using intelligence gathering of information. A model that will monitor, gather and record intelligent data regarding their operations is developed and simulated using Unmanned Aerial Vehicle (UAV).

The rest of the paper is structured as follows. In Section II, the method used in the development of the proposed model, mathematical modelling is also presented. In Section III, the results and discussion of the performance of the UAV simulation is presented. Section IV concludes

2. EXPERIMENTAL METHODS

UAV, also called a drone; is an aircraft without human pilot on-board has gained wide acceptance and usage in recent times basically due to its low-cost, numerous military and civilian applications, ranging from surveillance, agriculture, communications archaeological exploration, photography, public services, aerial mapping, and search and rescue operations [2-4]. It is equipped with lots of very sensitive devices like camera and sensors (LiDAR, thermal, radar), powered by batteries and remotely piloted or controlled using ground control station (GCS) – ground cockpit that transmits commands through wireless means to the aircraft, or it can fly autonomously using an on-board computerized navigation system which makes it an intelligent.The features of the perimeter hybrid electric drone by Skyfrontshown in fig. 1 was used for this research work because they were designed to operate for longer time over a long range approximately 50km away from the operator.

Fig. 1 The perimeter hybrid electric drone by Skyfront [5]

The area mapping of the target region in Oyigbo LGA, River stateas shown in fig. 2 was obtained using Google earth pro and GIS software.

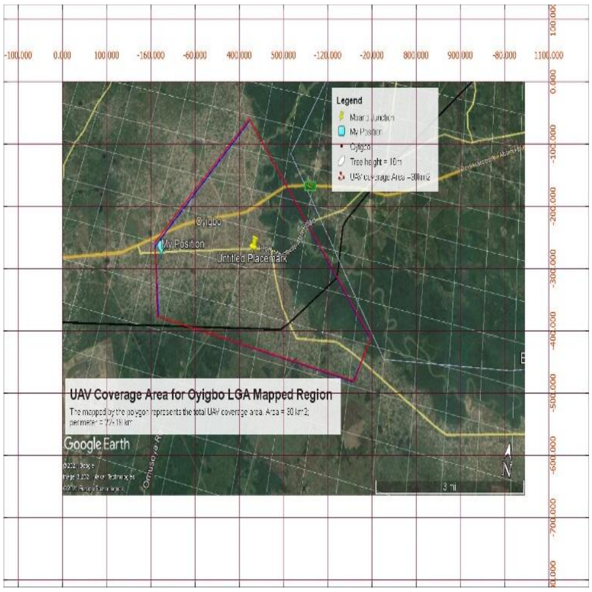

Fig. 2 UAV's Coverage Area for Oyigbo LGA Mapped Region

In the mapping of the study area the following factors that could affect the efficiency and deployment performance of the UAVs were considered.

i. The size and shapes of the interest area
ii. The static constraints (e.g. Forest woods)
iii The dynamic constraints (e.g. automobiles).

The tree heights figure and other heighted obstacles were mapped in the course of this work, because they fall under factors that could affect the efficient and deployment performance of the UAV during its path trajectories; knowing their heights and positions is necessary for collision avoidance.

Mathematical Model

i. Determination of Required Number of Ground Control Station.

The ground control station (GCS) sends wireless commands to the UAV remotely from very long distances. The number of required ground control station can be determined by making the following assumptions:

1. control range from the GCS to the UAV is a square of 50 Km
2. length of field of View (FOV) of our camera is 3km, and the UAVs
3. the maximum altitude is h.

From [6] the camera's FOV can be calculated as follows:

$$W = 2h * tan\left(\frac{\alpha}{2}\right) \quad (1)$$

$$L = 2h * tan\left(\frac{\beta}{2}\right) \quad (2)$$

$S_{FOV} = W * L$ (3)

$S_{cell} = (1 - d) * S_{FOV}$ (4)

Where:

W = the width of FOV

L= the length of FOV

h= the UAV flight altitude

α= The vertical degree of the camera

$\beta =$ The horizontal degree of the camera

S_{FOV} = area of camera's FOV

S_{cell} = area of sampling cell

d= overlap rate

Assuming that $\alpha = 80^o$ and $\beta = 40^0$, and L = 3km. Solving the above equations, the width of FOV is W is 1301 m, the UAV flight altitude h is 1787.6 m and the area of camera's FOV is 3.9km^2.

The size of our mapped area is approximately 30km^2; which implies that one GCS has the capacity to cover our entire area of interest.

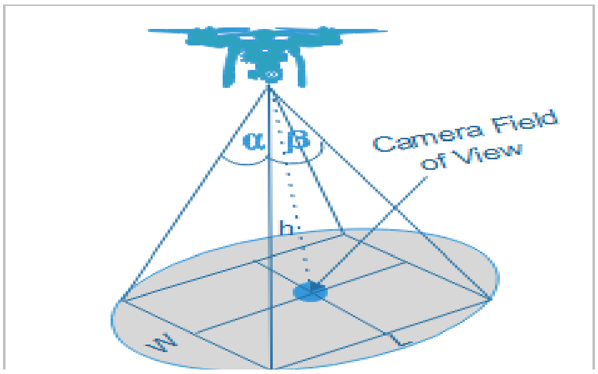

Fig. 2 Camera FOV

ii. *Determination of Path Planning*

The path planning techniques utilized in this work fall under the geometric technique - a pure pursuit and carrot-chasing algorithm. This type of algorithm performs its control within a predefined point, lines and planes, it deals with dynamic targets. The workplace was represented using empty grid map, with nodes and waypoint in the free space, the waypoints are followed by the UAV, which steers towards the virtual target point (VTP); the virtual target point in turn is updated along the path with a constant look-ahead distant so as to maintain the pure pursuit strategy. The pure pursuit is a very reliable path tracking algorithm that adds up the angular velocity command that drives the UAV from its current position to reach the look-ahead distant in front of the UAV; whereas, the carrot-chasing strategy make sure it steers the UAV towards the virtual target point that is located some points away on the path.Figures 3 and 4 show the workplace sampling and a flight planner flowchart respectively.

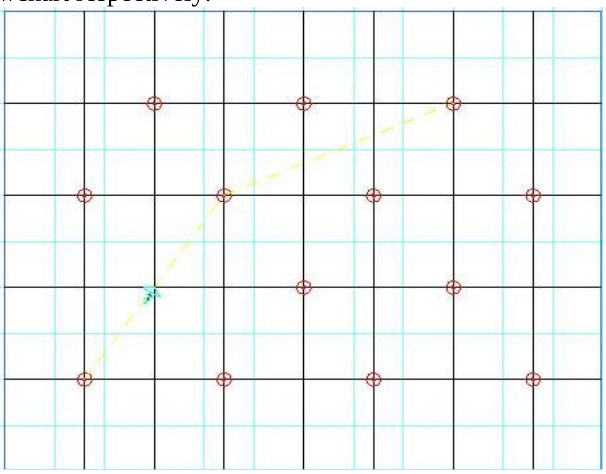

Fig. 3 The workplace sampling area

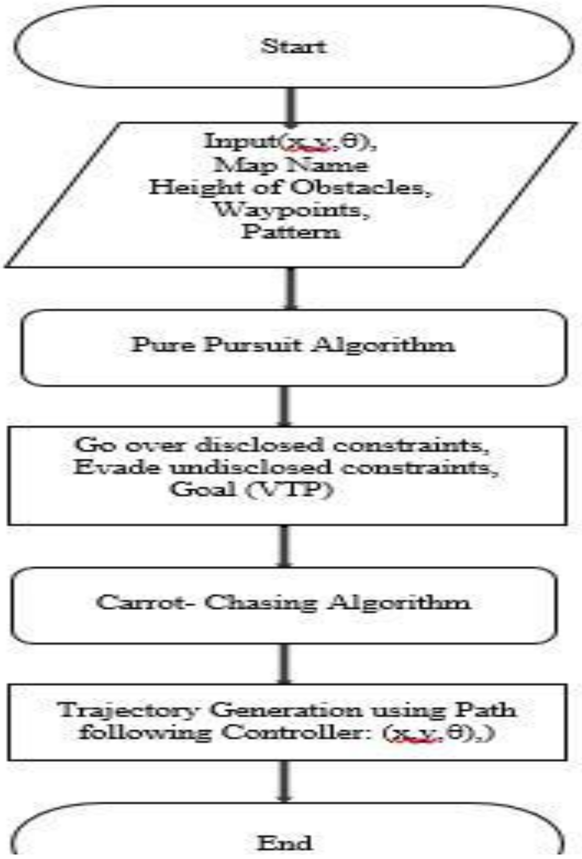

Fig. 4 A flowchart of Flight Planner

TABLE 1 *Considerations for the modelling of the UAV*

Parameters	Pure pursuit (Empty grid)	Carrot-Chasing (Mapped region at absolute height)	Carrot-Chasing (Simple Grid Map with Constraints)
Linear Velocity	0.85	0.9	0.7
Angular Velocity	2	2	2
Look-ahead Distance	0.95	0.99	0.8
UAV Radius	0.5	0.7	0.8
Goal Radius	0.1	0.1	0.1
Initial Orientation	0	0	0
X limit	0-16km	0-25km	0-25km
Y limit	0-16km	0-25km	0-25km

RESULTS AND DISCUSSION

Figure 5 shows UAV simulation with an empty grid map using a pure pursuit controller: An empty grid map here means that the UAV manoeuvres through it the waypoint without regards to any imaginary or real grid-lines during its trajectory. In this simulation, the input waypoints (x, y) coordinates were defined, and used for the UAV's velocity commands; the UAV's current position was taken with reference to its input parameters and orientations (see Table 1 for list of input parameters). Once all the required parameter values are inputted, the angular velocity was computed by the pure pursuit controller to move the UAV from its current position to the goal position using the look-ahead distance as a guide.

It is worth noting that to avoid having unstable path following behaviour, the look-ahead distance has to be greater than the linear velocity. Figure6 shows the trajectory of the UAV in the course of a single flight at absolute height with hovering and monitoring function by Carrot-chasing algorithm; in this way, the UAV steers towards the virtual target point (VTP). A VTP is a virtual point place at some point along the waypoint of a UAV path during trajectory; to get the VTP, a constant distance (length) is added to the UAVs nearest point on its path along the waypoint, this guides the UAV while moving at a constant speed, to steer towards the VTP by changing its coordinate.

Furthermore, the virtual target point in turn is updated along the path with a constant look-ahead distant located some points away on the path. This process continues till the goal point is realized and the UAV returns to the starting point. It is expected in real life scenario at this point that UAV would capture the images as it hovers along its waypoints, and transmit wirelessly through a local area network (LAN) to the GCS for further processing depending on the required information.

In figure 7, unlike the previous scenario where the UAV have to fly above the heights of obstacles in the area, this model has to evade multiple constraints, not by going over them as shown in the previous scenario, but by employing its LiDAR and radar sensors to navigate through its waypoints, achieve its goal and back to the starting point.

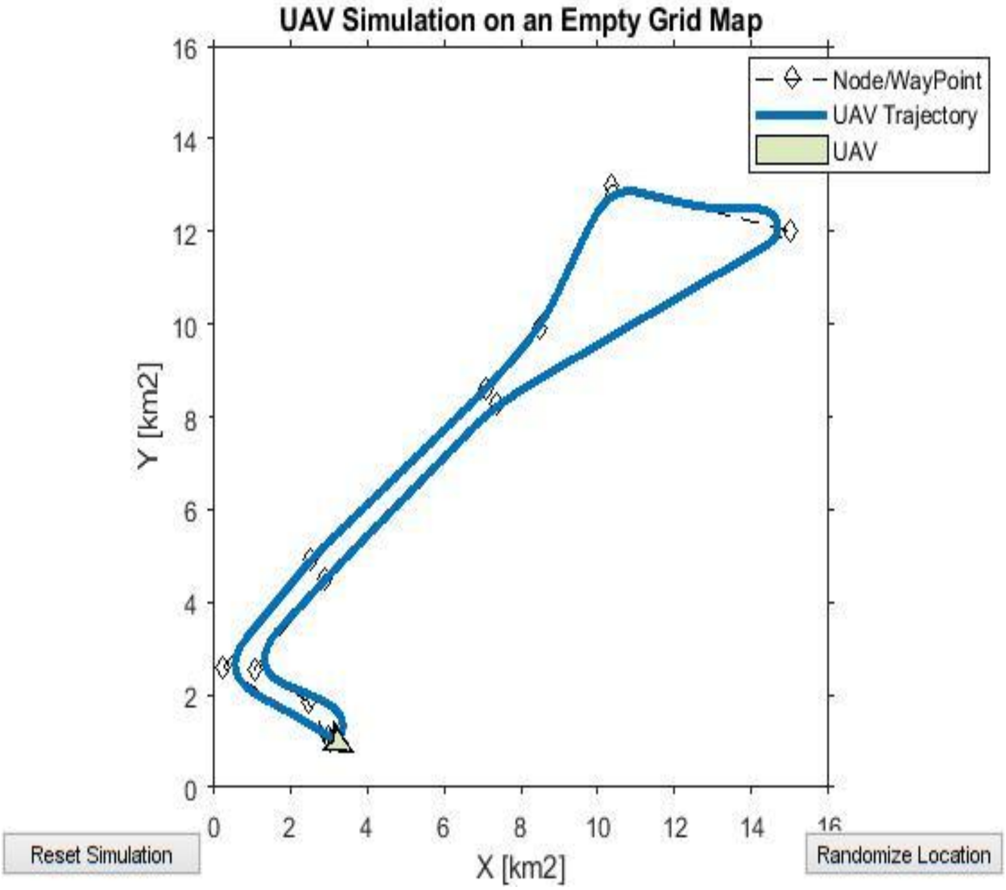

Fig. 5 UAV simulation with an empty grid map.

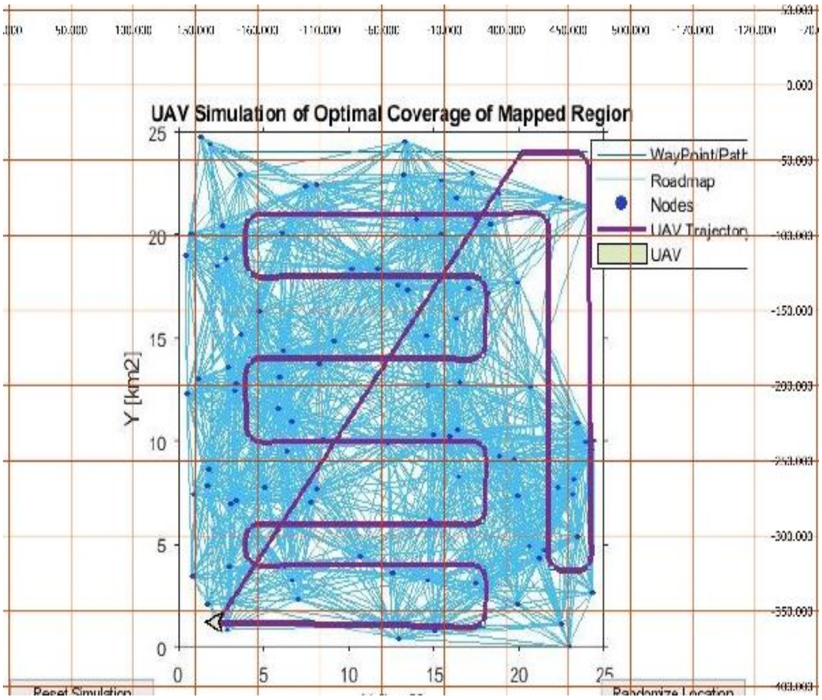

Fig. 6 Optimal Coverage Simulation of Mapped Region with UAV at Absolute height

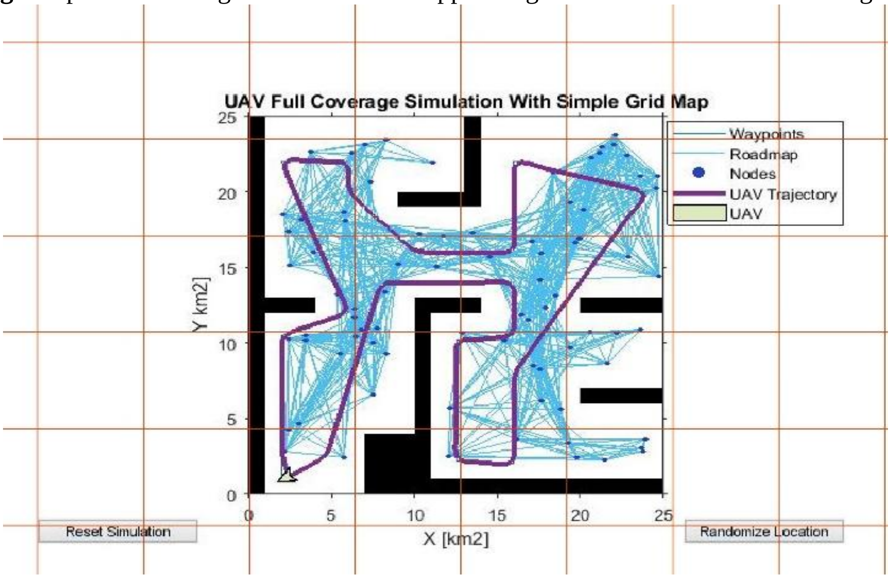

Fig. 7UAV Plots of Waypoints for Simple Grid with Constraints.

CONCLUSIONS

The study examined the UAV surveillance for intelligence gathering. The coordinates of the study area were obtained using Google Earth Pro and QGIS software. The simulation was performed in MATLAB to obtain theUAVs path plan using pure pursuit and carrot-chasing algorithms. The required number of ground control station was determined, and the simulations results show that the interested mapped region was optimally covered by the UAV using the proposed method.

REFERENCES

[1]. Abdulbaqi, S.S. and Ariemu, O., 2017. Newspapers framing of herdsmen-farmers' conflicts in Nigeria and its implication on peace-oriented journalism. *Creative Artist: A Journal of Theatre and Media Studies*, *11*(2), pp.77-105

[2]. Zhang T. and Chen, X. (2017). Deployment of Real Time UAV Aerial Surveillance with Coverage Model. https://scholar.uwindsor.ca/etd/7412

[3]. Matthew, U.O., Kazaure, J.S., Onyebuchi, A., Daniel, O.O., Muhammed, I.H. and Okafor, N.U., 2021, February. Artificial Intelligence Autonomous Unmanned Aerial Vehicle (UAV) System for Remote Sensing in

Security Surveillance. In *2020 IEEE 2nd International Conference on Cyberspac (CYBER NIGERIA)* (pp. 1-10). IEEE.

[4]. Mozaffari M, Saad W, Bennis M, and Debbah M. (2016). Communications letters, *Efficient Deployment of Multiple Unmanned Aerial Vehicles for Optimal Wireless Coverage*. 20(8),

[5]. NamL.H,Huang L, Li X.J, and Xu J.F. (2016). Advanced motion control. *An Approach for Coverage Path Planning for UAVs*

[6]. Skyfront Perimeter Drone - Long-Range Surveillance Drones https://www.skyfront.com/

[7]. Rubi B, Perez R and Morcego B (2020). Intelligent and robotic systems. A Survey of Path Following Control Strategies For Uavs Focused on Quadrotors.