Development of Energy Efficient For UAV

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Abstract: **The development of energy efficiency in unmanned aerial vehicle operations was proposed in this work. Tremendous and remarkable achievements have been recorded in the area of unmanned aerial vehicle operations with regards to energy efficiency. The principal aim of energy efficiency while maintaining accurate collision avoidance. Characterization of the energy consumption of a conventional unmanned aerial vehicle was first carried out, then, A successful characterization was followed by development of a Simulink model of the conventional unmanned aerial vehicle with the characterized parametric values as input for simulation. With a reliable simulation result, then a model on energy efficiency was developed. This model was simulated in order to validate and justify the work. Velocity and energy-time graphs were plotted to show the relationships of velocity and time of unmanned aerial vehicle flight as well as energy expended and time. Computations from the plotted graphs show an energy efficiency of 8.3% over a conventional operation of unmanned aerial vehicle without the application of the technique in this research. This is the percentage of improvement. It is a justification and validation of this research on the use of energy efficiency in unmanned aerial vehicle operations. It has been established that energy consumption in unmanned aerial vehicle operations is influenced by its mode of operation at a given time. There is an obvious reduced running cost with energy efficiency.**

***Keywords*: Energy Efficiency, unmanned aerial vehicle, Unmanned Aircraft System, Modified Tentacles Algorithm.**

I. INTRODUCTION

An unmanned aerial vehicle or remotely controlled aerial vehicle, is an aircraft which operates without a human pilot on board. It is essentially an unscrewed aircraft. Form part of a family known as unmanned aircraft system made up of unmanned aerial vehicle, a ground base controller and a system of communications between the two. Unmanned aerial vehicles maintain certain degrees of autonomy during flight, maintained by either remote control by human operators or onboard control computers. Unmanned aerial vehicles are generally known as drones and guided autonomously, by remote control, and carry sensors, target designators, offensive ordinance or electronic transmitters designed to interfere with or destroy enemy targets when used in military operations (Guilmartin, 2019). Due to the increase in the number of multiple unmanned aerial vehicles for technical and other applications, there has been increased interest in the study of embedded sensor and communication devices. Every day, available civil, commercial and even military applications of unmanned aerial vehicles motivated this growing interest. , there is the need to improve on the energy efficiency of unmanned aerial vehicles. , there is need to reduce energy usage necessary to achieve this. Achieving collision avoidance with obstacles by unmanned aerial vehicles at a longer time means expending more energy and hence technically not viable. The consequence is excessive energy usage. This problem is being addressed in this research by applying the modified tentacles algorithm implemented using model in MATLAB/Simulink environment as a tool to achieve a combined effect of both precision in collision avoidance as well as increased energy efficiency. For a unmanned aerial vehicle to be said to operate optimally, there is need for it to efficiently utilize energy in order to achieve its operational goals comprising range, endurance and other specific critical mission requirements. As a result of the inherent limitations arising from the available space and tight running budget in its operation, there has always been a sharp contrast between the achievement of its operational goals, the onboard available energy(1) According to the authors, three methods were listed as capable of achieving energy efficiency in unmanned aerial vehicles operations. These are:

- Optimization of mission waypoints.
- Use of hybrid-Electric Propulsion System.
- Use of effective power management systems.
- Energy efficiency has never been considered in the trajectory path planning as focus was centered on iterative optimization. Energy efficiency is also given additional consideration. Thus, this research is predicated on efficient energy usage in a quick avoidance of collisions by multiple unmanned aerial vehicles. Without prejudice to all that have been said so far, additionally, less energy will be expended even with this seemingly increased precision. This paper deals with (1) a characterization to determine the existing energy consumption rate of a conventional unmanned aerial vehicle with respect to time, then, (2) development of a model using the data obtained by the characterization, and then, (3) a proposed an algorithm and developed a model for the energy efficiency, and Finally, (4) evaluation and validation of the results were carried out in other to justify the research work.

II. MATERIALS AND METHOD

The materials used in this research are articulated below

- Stop watch Time measuring instrument

- Physical model of UAV
- Frequency synthesizer for seamless communication and monitoring
- UAV model in Simulink
- Video display units (VDUs) for monitoring UAV Operations in the simulations
- Display terminals
- Computer system

III. METHODOLOGY

To characterize the existing energy consumption rate of conventional unmanned aerial vehicles with a view to establishing its volume and level with respect to time. The flowchart for the implementation of objective one is shown in Figure 1. It was required to characterize the existing energy consumption of a close range unmanned aerial vehicle. Being a close range category, the unmanned aerial vehicle was meant to be flying between the ranges of 1km to 25km in its total operation which was one hour. The emphasis in this objective is energy consumption while maintaining its normal obstacle avoidance capability.

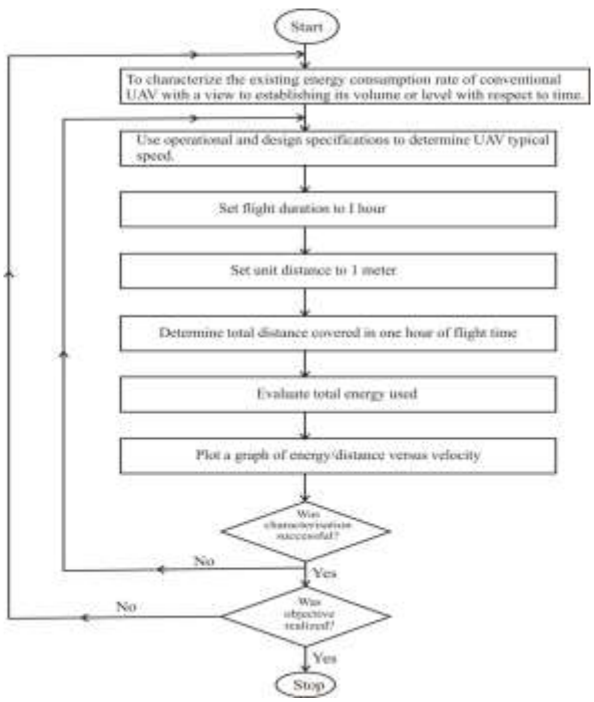

Figure 1: Flowchart for Implementing characterize the existing energy consumption rate of conventional UAVs with a view to establishing its volume or level with respect to time.

Equations

Velocity/UAV speed equals $10ms^{-1}$

Flight duration equals 1 hour

Energy use per unit distance equals 20 Joules/meter

From the above basic data the following derived parameters can be got

1hr flight = 10m x3600 =36000m/h =36km/hr

In 1hr the UAV covers a total of 36000m

Total energy consumption

Energy = 20J x36000

Energy = 720000J = 720KJ

Conventional energy/distance UAV used to cover an area K.E = 20J/m

Simulated energy/distance UAV used to cover an area K.E1 = 18.34J/m

$$\text{Energy efficiency} = \frac{K.E - K.E1}{K.E} \times \frac{100\%}{1}$$

$$\text{Energy efficiency} = \frac{20 - 18.34}{20} \times \frac{100\%}{1}$$

Energy efficiency =8.3%

Table 1: Characterized data of energy consumption of a typical unmanned aerial vehicle using Hydrocarbon combustion fuel.

Velocity/UAV speed	$10ms^{-1}$
Total Flight Time or Duration	1hr or 3600seconds
Energy used per unit distance	20J/m
Total distance	36000m or 36Km
Total Energy or Energy Consumption	720000J or 720KJ

The parametric data in Table 1 are derived given the preliminary information before generating the table. These data are then used to develop the required model of objective two.

To develop a model of the existing energy consumption rate of conventional UAVs, Figure 2 shows the flowchart for the implementation of objective two.

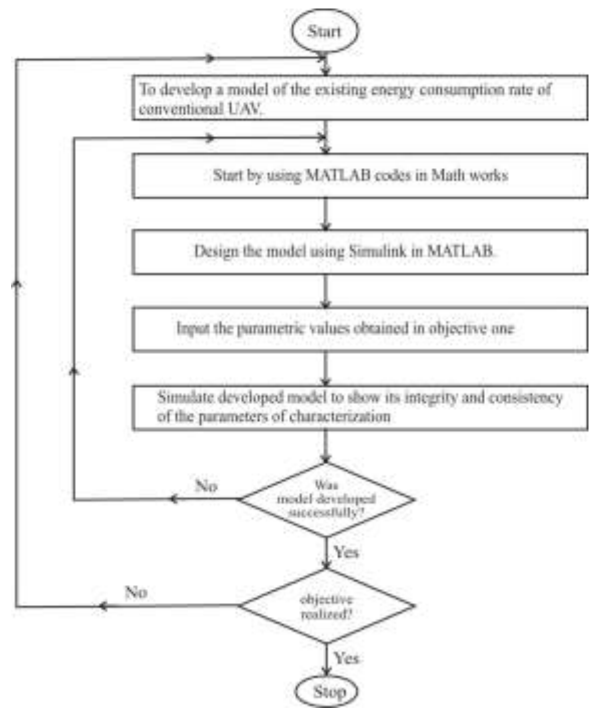

Figure 2: Flowchart for the implementation of a model for existing energy consumption rate of conventional UAVs

In this objective, the data got after the characterization of the UAV's energy consumption is used to model a conventional UAV in this mode of operation. This was done in Simulink environment in MATLAB. After developing the Simulink model, the parametric values obtained as a result of the characterization were used as input into the model which was subsequently simulated. The developed model is shown in Figure 3.

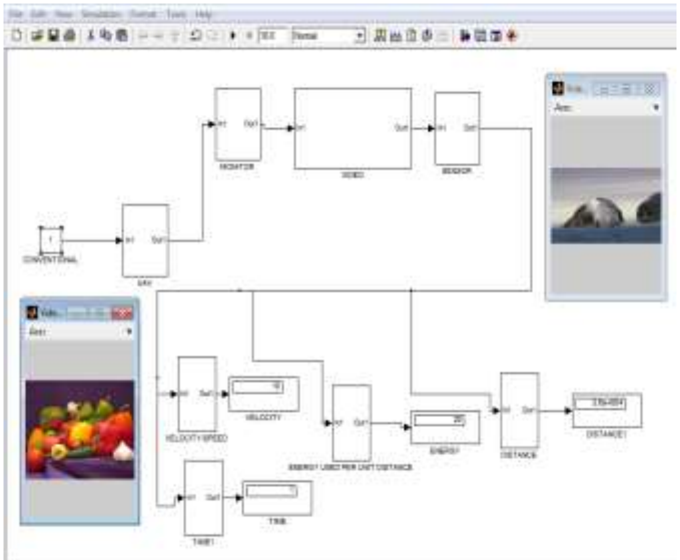

Figure 3: A Model of the Existing Energy Consumption Rate of Conventional UAV

Figure 3. Shows a model of the existing energy consumption rate of the conventional UAV in normal flight operation without the application the tentacle algorithm. When simulated, the various parametric values of the characterization data were shown in the resulting output.

IV. RESULTS AND DISUCSSION

Results of the characterization of UAV energy consumption

It has been observed that the energy used or expended by a drone or UAV to deliver a package and execute an operation depends on the flight duration and speed of travel. Depending on the mission, it is usually advised to minimize the energy used in its operation to ensure optimality. Estimation of the power consumption of the UAV was carried out using a suitable procedure for the purpose of the characterization exercise.

There are three modes of UAV flight. These are:

- Lift mode,
- Line of sight or Cruise mode, and
- Landing mode.

In the lift mode, the unmanned aerial vehicle struggles against the force of gravity thereby expending a lot of energy to overcome it. The speed of flight is lowest during this mode. When it attains the desired altitude, the operator may choose to minimize the use of energy by selecting the appropriate velocity of operation. In this research, it was intended that the unmanned aerial vehicle was for communication purposes. Thus, the unmanned aerial vehicle was meant to perform optimally during a total flight time of 1 hour or 3, 600 seconds. 10 m/s velocity was configured. Flying at a velocity of 10 m/s for 3,600 seconds gives a total distance of 36 kilometers. A graph of Energy per distance on the Y-axis versus velocity on the X-axis shows the characterization relationship with respect to energy and velocity of the unmanned aerial vehicle in this research. Figure 4. Shows graph of energy/distance versus velocity relationship.

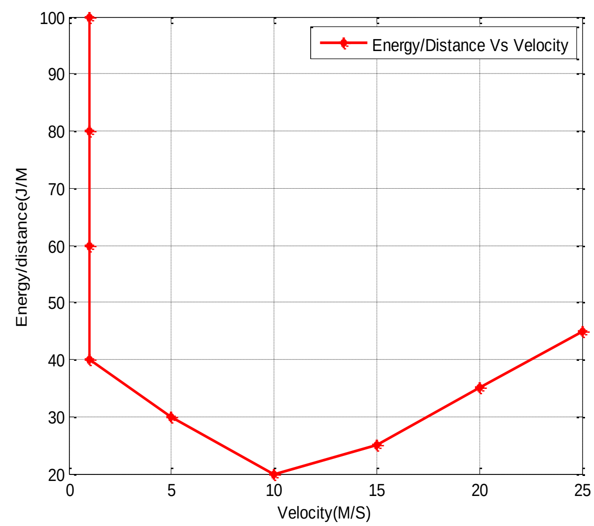

Figure 4: Graph of Energy/Distance versus Velocity

As shown in Figure 4, a graph of energy/distance in Joules/meter versus velocity in m/s was plotted showing the energy consumption in conventional unmanned aerial vehicle operation. Given an operational speed or velocity of 10m/s, the energy was 20J/m. thus, starting from take-off point, energy use decreases steadily until the unmanned aerial vehicle stabilizes at its optimal velocity of 10m/s which is regarded as its cruise speed. This means that more energy is required during take-off than at cruise or landing point. The model was made up of several parts meant to perform different functions in order to enhance optimal performance of the unmanned aerial vehicle operating under conventional mode. This is the mode where no energy efficiency technique was applied. The different functional parts are discussed with respect to their functions in the developed conventional model. When an input is made and the model is simulated, a view of the unmanned aerial vehicle flying past and among several obstacles was observed. The simulation result also shows a display of the earlier obtained characterized parametric values as a conventional operating unmanned aerial vehicle.

The module as shown in Figure 5, is made up of An input and output nodes. Between these nodes, there are math function differentiators and integrators meant to exhibit the operational functions of the unmanned aerial vehicle in a conventional sense.

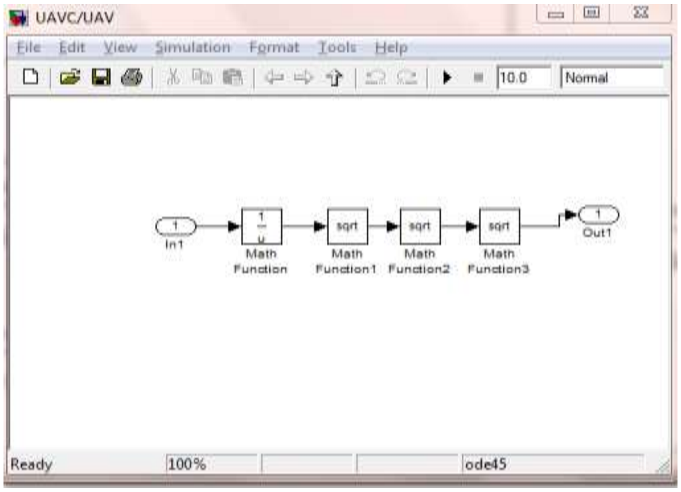

Figure 5.: UAV Module of the Conventional Simulink Model

The next module is the monitor which monitors the input data for identification and interpretation.

Another very important module is the video unit where several activities and operations are carried out. Its internal layout is shown in Figure 6.

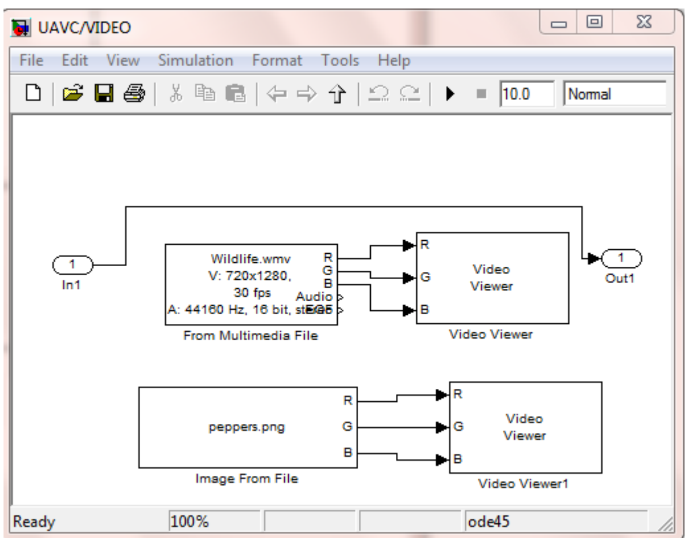

Figure 6: Video Unit of the Simulink Model of the Conventional UAV

The four sections of the video unit are the multimedia file, video viewers 1 and 2 and .png file. Simulated view of the set-up is shown in video unit. There is also the sensor module from where the conventional input is fed into the system for analysis and output result. The velocity unit and time 1 were connected on the same node together with the energy used per distance. After the design and assembly of this model in Simulink, it was simulated to show its compliance with physical data obtained from characterization in objective one. As shown through the display points, the simulation results were consistent with the results obtained after characterization. This shows that the objective was realized to the fullest. Table 2 shows the result of comparison between conventional and MTA energy usage given the same time of operation. These data were got from simulation results of the integrated Simulink model.

Table 2: Comparison of conventional and modified tentacle algorithm UAV energy usage

Time(s)	**Conventional UAV Energy (Joule)**	**Modified Tentacle Algorithm UAV Energy (Joule)**
0	0	0
2	18	16
4	20	18.34
6	20	18.34
8	20	18.34
10	10	18.34

Similar to what is obtained in the velocity-time graph and energy-time graph, the MTA based unmanned aerial vehicle used less energy as well as less speed after attaining its cruise condition. Thus, the plotted graph showed reasonable level of energy efficiency in the operation of the modified tentacle algorithm based unmanned aerial vehicle over the conventional unmanned aerial vehicle operation. These plotted simulation results were used to validate and justify this research. The unit of the energy-time graph produces what is called angular momentum which also appears in quantum mechanics in the description of Planck's constant.

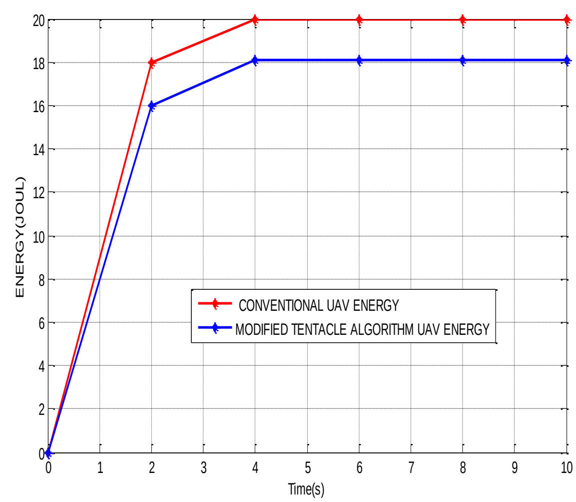

Figure 8: Energy-Time Graph of Conventional and MTA based UAVs

In this simulation, it was required to evaluate and validate the results obtained and hence justify the research. The result of the just computed energy calculation showed that less energy was expended when the unmanned aerial vehicle was operated in modified tentacle algorithm mode than in a conventional mode. The percentage of energy efficiency has been shown to be 8.3% and 1.66J better when an unmanned aerial vehicle is configured in the modified tentacle algorithm mode than in a conventional operation. This position holds for the justification of this research. These graphs were velocity-time graph and energy-time graph. Finally, the percentage of energy efficiency was calculated to be 8.3%. This showed that with the use of MTA, energy efficiency to the level of 8.3% was achieved.

V. CONCLUSION

This paper was focused at evolving strategic energy efficiency in unmanned aerial vehicle operations using modified tentacles algorithm. In the course of this paper work, it was to establish that three different modes in unmanned aerial vehicle operation greatly influence the amount of energy it expends in order to achieve its operational goals. These three modes are the life mode, line of sight and landing mode, respectively. Also the energy used by unmanned aerial vehicle to carry out an assigned operation depends on the flight speed as well as flight duration. First, was the energy consumption rate of conventional unmanned aerial vehicle was characterized in order to establish its volume with respect to time. Then the development of a model using the data obtained by the characterization and then, a proposed an algorithm and a developed model for the energy efficiency. In the impact of the modified tentacle algorithm especially with regard to tentacle selection which enhances responsive obstacle detection and avoidance was seen to play a determining role in energy usage and efficiency. In conclusion, the achieved results showed that the modified tentacles algorithm brings about a better collision avoidance unmanned aerial vehicle and energy efficient operation as well.

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