DRONE SIMULATION FOR MILITARY SURVEILLANCE IN THE NORTH-EAST OF NIGERIA

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ABSTRACT
The paper presents new simulation tools that are capable of controlling, coordinating, manipulating, detecting and tracing of drones in the North-East of Nigeria where the activities of terrorist group popularly called Boko Haram is highly dominated. Simulation of the environment for a modern human being has become necessity allowing him to increase his work efficiency and ease of comfort. There has been immense development in the area of an individual's routine tasks and those can be simulated. Simulation is an imitation of the operation of a real-world process or system. Simulation can be used in many contexts, such as performance optimization, testing, training, education and video games. This program we intend to develop will show the eventual real effects of alternative conditions and courses of action. We will use simplified approximations and assumptions within the simulation, fidelity and validity of the simulation outcomes. The simulation process is done using Object-Oriented simulation tools. The process is monitored on the screen or display for clarity purposes for onward satisfaction of the viewer.

KEYWORDS: Drones, Simulation, Simulation Tools, Real World Process, performance optimization

I. INTRODUCTION

In this modern era of development, simulation of everything is the need of the hour. The basic aim of any development is to ease human life. The simulation aims at simulating human lives. Activating and simulating almost every appliance without a conventional switch but by using a smartphone or small device. Simulation is the use of one or more computerized remotes to control basic electronic/natural systems functions and features**.** With the development of science and technology. There is a huge focus on reducing manpower and increase in simulation & autonomous systems, to achieve higher accuracy, fast rate, and reducing risk on human life. Almost all the sectors are getting simulated nowadays. An Unmanned Aerial Vehicle (UAV), also known as a drone, is an aircraft with no human pilot on board. UAVs' flight can be controlled either autonomously based on pre-programmed flight plans with onboard computers, or by the remote control of a pilot on the ground or in another vehicle. UAVs are defined as “remotely piloted or self-piloted aircraft that can carry cameras, sensors, communications equipment or other payloads” [1].

Computer simulation is the reproduction of the behaviour of a system using a computer to simulate the outcomes of a mathematical model associated with said system. Simulations have become a useful tool for the mathematical modelling of many natural systems in physics (Computational Physics), astrophysics, chemistry, climatology, biology and human systems in economics, psychology, social science, manufacturing, health care and engineering. Simulations are realized by running computer programs that can be either small, running almost instantly on small devices, or large-scale programs that run for hours or days on network-based groups of computers. Because of the computational cost of simulation, computer experiments are used to perform inference such as uncertainty quantification. A computer model is the algorithms and equations used to capture the behaviour of the system being modelled. In contrast, computer simulation is the actual running of the program that contains these equations or algorithms. Simulation, therefore, is the process of running a model. Thus, one would not "build a simulation"; instead, one would "build a model", and then either "run the model" or equivalently "run a simulation".

II. RELATED WORK

The literature reports a large number of agent simulation environments but only a few of them considered the physical environment, physical constraints and provides 2D/3D display capabilities. NetLogo is one of the most popular toolkits for agent simulation; it is Java-based and can perform a simulation of a large number of agents. Agents live in a virtual environment which is bi-dimensional and discretised into small square cells: each cell can be occupied by a (static) environment element or by a (mobile) agent. Ad-hoc language is provided to model the behaviour of agents that can live, move and interact in the 2D environment. Besides these simple environmental aspects, NetLogo is neither able to simulate real-world physics and dynamics of entities nor to provide a 3D display.

Tridimensional capabilities are instead provided by Breve, a 3D environment for the simulation of decentralized systems and artificial life. It allows the designer to simulate the continuous-time and 3D space by including an interpreted object-oriented language, an OpenGL display engine, as well as the support for body physical simulation and collision resolution. In the work, the Agent behaviour is implemented in JavaScript and ThreeJS 3D Library, another easy-to-use language.

When compared to manned aerial vehicles, UAVs are believed to provide two important benefits - they are cost-effective and reduce the risk to a pilot's life. However, accident rates in today's UAVs are over 100 times than that of manned aircraft. Therefore, improved safety and reliability is still required. In Figure 1, the General Atomics MQ-9 Reaper (formerly named Predator B) is UAV capable of remote-controlled or autonomous flight operations, developed by General Atomics Aeronautical Systems (GA-ASI) primarily for the United States Air Force. UAVs are also referred to as drones [2]

Fig1: MQ-9 Reaper in flight. USAF photographic archives

UAVs are currently used for several missions, usually deployed for military and special operation but also reconnaissance of military and civil applications. To name a few, UAVs domestic applications include search and rescue, weather forecasting, law enforcement, border patrol, firefighting, disaster response, precision farming, commercial fisheries, scientific research, aerial photography, mail delivery, communications relay, infrastructure monitoring and emergency management.

UAV technologies are often centred on military conflicts reaching back as far as 1863; two years after the start of the Civil War, an inventor from New York City named Charles Perley registered a patent for an unmanned aerial bomber. During the Vietnam War, the US developed technologically advanced UAVs known as Firebee. This vehicle was unique in defining a new role for UAVs photo-reconnaissance aircraft. Surveillance was found to be the ideal mission for UAVs, Firebee can sustain longer flights at higher altitudes suitable for surveillance task [3]

Since then, they are capable of carrying a lethal or nonlethal payload and come in different sizes, from the size of an insect to that of a commercial airliner. These devices have proven their effectiveness in recent war zones, such as Kosovo, Afghanistan, and Iraq, giving them mass media exposure. Continued UAVs advancement heavily depends on technological innovation such as the Global Positioning System for navigational and targeting functions. The network-centric operations between UAVs potentially reduce human involvement and ground support and that enables UAVs capable of making autonomous decisions without human intervention.

Due to the improvements in embedded computing, communications, and sensing technologies, UAVs have become increasingly capable of carrying out sophisticated tasks. Most notable tasks that are ultra-long-endurance and high-risk mission acceptance, which cannot be reasonably performed by manned aircraft, however, can be done with UAVs [4].

a) Current Technological Development of UAV Systems

The current technological development of UAV systems are fast, however, it is difficult especially during testing due to potentially dangerous operations, site availability, considerable resource requirement, and weather conditions. Therefore, computer simulation is the best tool used to model and study complex systems. Simulation can be performed before the development of the actual system or without changing the existing system. A simulation receives a set of input values from the analyst, runs for a specified amount of time or number of replications, and outputs the result in terms of a performance measure.

UVA computer simulation can allow you to see how a system might respond before you design or modify it. This avoids mistakes and one can try different ideas before the real product is produced, making it cheaper as there is no need to make different prototypes every time and testing them out. It is an advantage to find this out in a model rather than testing the real thing [5]

b) The main danger of using the drones

The main danger of using the drones is the fall of a drone from a great height, which may be due to the discharge of the battery, damage caused by weather conditions (low air temperature, precipitation), hitting an obstacle (tree, building, high-voltage line).

III. ARCHITECTURAL DESIGN OF THE SIMULATOR

Agents have the capabilities to communicate with their peers by means short-distance communication, and with a possible base station through a long-range system; both kinds of channels support unicast and broadcast communication. These kinds of communication are handled by classes Message Transceiver and Message Dispatcher.

a) The architecture of the Simulator

The software simulator described in this paper is written in JavaScript and ThreeJS 3D Library; its simplified class diagram is reported in Figure 1. It is composed of three main modules: Core, UAV and GUI.

The **Core** consists of the classes that represent the basic entities of the simulator. The mission is the main class that has the responsibility of instantiating the simulator and starting the overall system; indeed, it reads a configuration file (in ".INI" format) that specifies all the parameters of the simulation, including the type of the agents employed, the presence of the

GUI, the size of the environment and other mission-specific items. This class creates, at start-up, an instance of the class simulator, which is a container that refers all the Agents instantiated in the simulation and the world, which is the class handling the physics and dynamics of agents.

b) (UAV)Unmanned Aerial Vehicles

The objective of the simulator is to study the behaviour of UAV-based applications; the UAV module provides all the necessary classes to simulate the behaviour and dynamics of UAVs. Two kinds of UAVs are simulated, which differ based on the commands that it can handle.

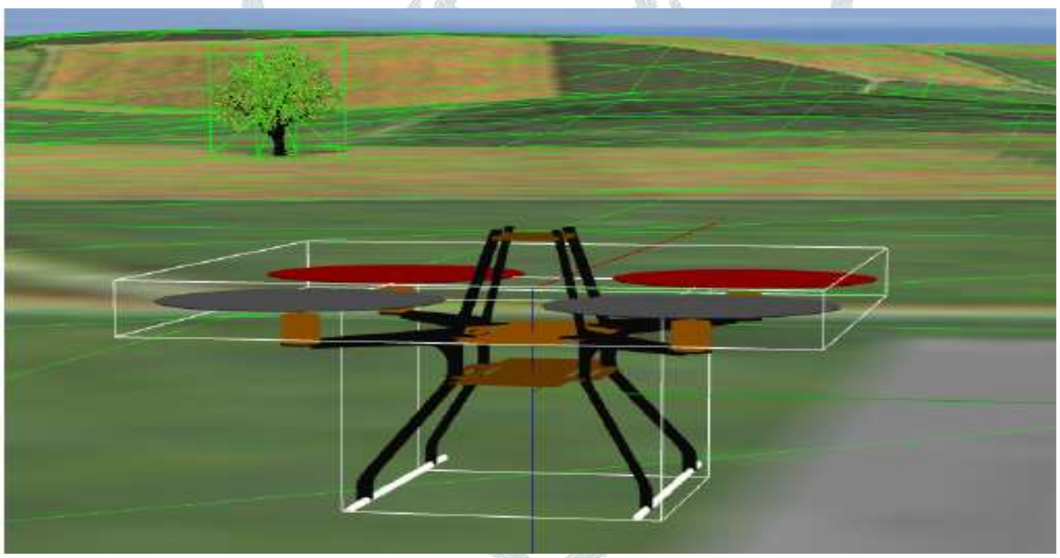

Fig.2. The graphical model of the UAV implemented in the simulator

The Core includes also the abstract classes Agent and Physical Agent that must be extended to implement the specific user-defined agent behaviour. These two classes are designed to make a distinction between logical and physical agents: the latter category includes agents located at a precise point in the simulated space/environment and with the ability to move, while the former category refers to other not location-aware entities that however live in the environment and needs to be simulated. Interaction among agents is also handled in the Core.

Each agent is uniquely identified by an id (class AgentIDType) that is indeed an integer.

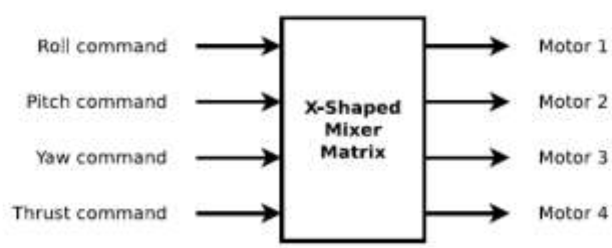

Fig. 3. Manual mode

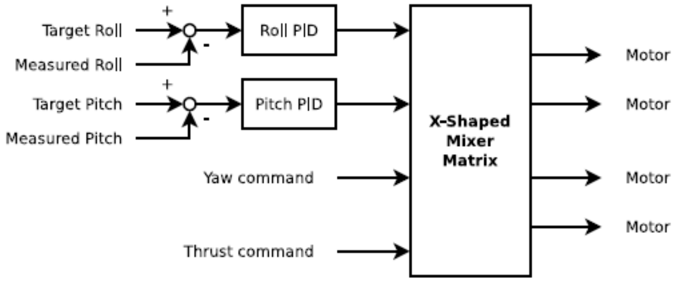

Fig. 4. Attitude mode

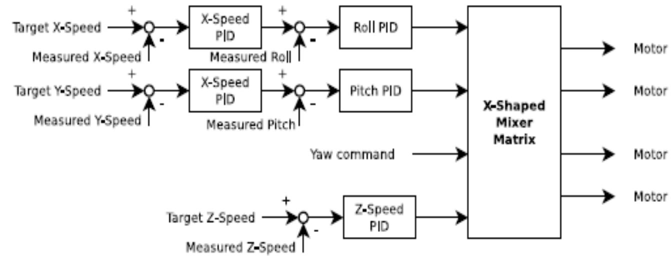

Fig. 5. GroundSpeedAndVertSpeed mode

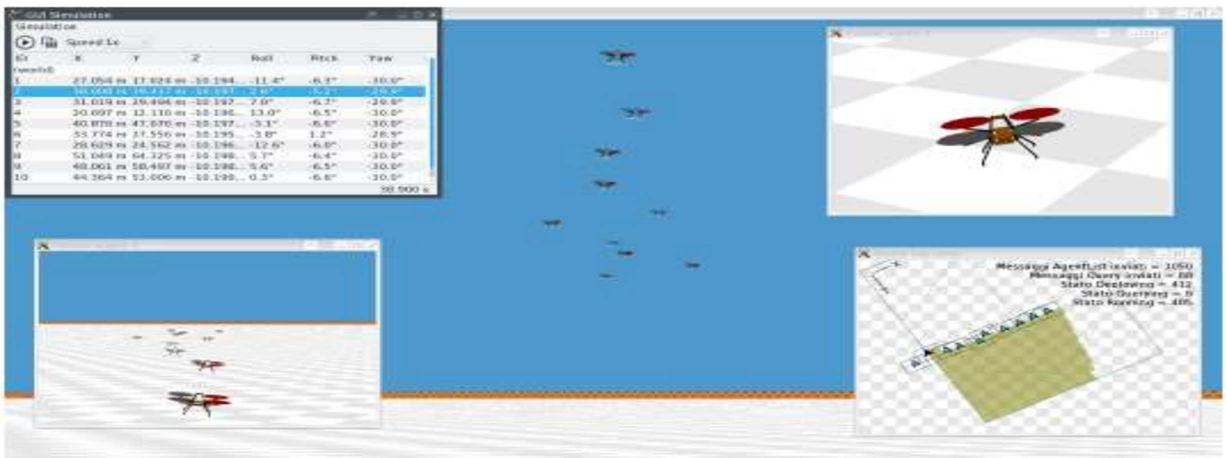

Fig. 6. A Screenshot of the Simulator

RESULTS AND DISCUSSION

The simulation has an interface that allows the user to choose certain parameters such as the number of unmanned aerial vehicles involved in the mission (varying from one to ten), enemy zone radius, the speed of the simulation from slow to fast, project the path of each UAVs, start and stop of the simulation, and reset after the simulation is started. Some of the parameters are set by default, the number of UAVs selected is 3, the enemy radius is set to be 10, and the speed of the simulation selected to be fast. Designing an item as a model on a computer before the real item is built saves time. Simulations can be slowed down to study behaviour more closely. Simulation models allow analysts and researchers to produce complex scenarios without changing the actual systems being modelled. Also, a simulation runs for a specified amount of time or number of replications and outputs the result. These specifications are important, for example for the drone's cruising range, the maximum flight duration, and the loading capacity. Aside from the drone itself (i.e., the ‘platform'), various types of payloads can be distinguished, including freight (e.g. mail parcels, medicines, fire extinguishing material, flyers, etc.) and different types of sensors (e.g. cameras, sniffers, meteorological sensors, etc.).

To perform a flight, drones need (a certain amount of) wireless communication with a pilot on the ground. Also, in most cases, there is a need for communication with a payload, like a camera or a sensor. To allow this communication to take place the frequency spectrum is required. The requirements for frequency spectrum depend on the type of drone, the flight characteristics.

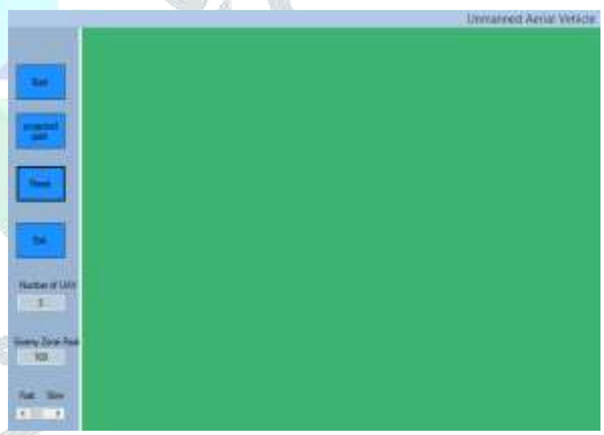

Fig 6: Flight controlling buttons, parameters, an area to display the flight

Fig 6 shows the graphical interface containing the flight Controlling buttons, parameter settings, and display area. To start the simulation, by default three aerial vehicles are selected with 100-unit radius of the enemy zone - a circular area centred at the target-controlled by the enemy, and fast-moving frames. These parameters can be changed before starting the simulation. The start button starts/pauses the simulation, projected path displays the projected path of the planes' track, reset button resets the current flight simulation to start over, this can be done at any time during the simulation, and also this button can be used to start a fresh simulation. To do that the current simulation needs to be paused and double-clicked on the reset button. The exit button closes the simulation.

CONCLUSION AND FUTURE WORK

Conclusively, the demand for UAVs in civilian and military world is sky-rocketing along with technological advancement, particularly autonomous aerial vehicles as they reduce human errors and a shortage of trained pilots. This paper addressed the simulation for unmanned aerial vehicles to launch from different airbases that are not predetermined to hit their target at the same time coming from a different angle. The results illustrated the flight path followed by autonomous UAVs for several cases where different numbers of UAVs participate in the battlefield to destroy the enemy targets. Military drones differ from that of a civilian in size and drive.

Although the maximum numbers of UAVs involved in the simulation are up to 1, the algorithm is scalable to more than 10 UAVs to be launched at the same time to accomplish their mission. In this simulation, the enemy zone, a strong enemy hold area, is scalable from a small size circular area measured from the target to a large area depending on the strength of the enemy defensive capability. But in all cases, the UAVs launched from outside the enemy zone and hit the target entering the enemy zone at the same time to reduce visibility and retaliation of the enemy. There are also some assumptions considered to simplify the design and implementation with less effect on the real-world case. This work can be extended by including additional constraints such as terrain and man-made structures, weather conditions, GPS on each plane to interact with each other. These additional parameters will make the simulation more realistic but come with higher computational time.

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