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UAV IMAGE MAPPING: AN APPLICATION IN MONITORING AND CONTROL OF CRIME AND INSECURITY

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ABSTRACT
Crime and insecurity of life and possessions continues to ravage our societies till date, and of inestimable value in combating crime and insecurity is availability of updated information about the hotspots of such occurrences. Such information is appreciable when presented in a graphical form. Representation of the real world entities in the graphical form on a plane surface or in a computer model is called mapping. Mapping is a tedious job especially when it comes to large area of coverage. Methods of ground surveying, photogrammetry, cartography and other terrestrial methods employed in the years past for data capture, processing, presentation and storage are rigorous, time consuming and limited in capacity. Unmanned Aerial Vehicles/Systems (UAVs/UASs) or Autonomous Vehicles (AVs) widely called DRONEs (an acronym for Dynamic Remotely Operated Navigation Equipment) which was originally designed for a military operation is now widely adopted for civilian activities and is no less important than it is for the military. But today UAVs/UASs for civilian applications are growing rapidly worldwide. Examples of the applications include mapping, real time monitoring, package delivery, aerial photography and videography, geospatial data collection, etc. This paper however focuses on the adoption of UAV for mapping and its application in combatting the increasing trends in crime and insecurity. It also suggests how DRONE technology can be adopted for real time crime monitoring and control. It also seeks to assess developments in the UAV's market and technologies as well as prevailing regulations on UAVs/UASs use for civilian operations in Nigeria.

INTRODUCTION
The early focus on UAS supporting the so-called "three Ds" (*i.e.*, dull, dirty, or dangerous missions in which human pilot operations would be at a disadvantage or at high risk) highlighted the natural niche for UAS. Improvements in reconnaissance and guidance capabilities during the Cold War spurred interest among the scientific community in utilizing UAS for science missions in which pilotless aircraft provided similar advantages and risk mitigation. The US National Aeronautics and Space Administration (NASA) developed unmanned aircraft for high-altitude atmospheric sampling during the "Mini-Sniffer" program of the 1970s–1980s, but with limited success, and little follow-on activities. NASA's Environmental Research Aircraft and Sensor Technology (ERAST) program in the 1990s marked the first major steps towards developing the protocols and capabilities for employment of UAS supporting scientific research. However, the military pedigree of most unmanned aircraft systems yielded a dichotomy in the nature of most systems: UAS capable of carrying powerful and accurate sensors tended to be large and very expensive, while small platforms lacked payloads to deliver precision data. The latter group of UAS was better suited to budgets or logistical demands of many research organizations, but had been designed for situational awareness as opposed to survey-grade data delivery. One of the major findings of the ERAST program and subsequent UAS science community workshops was the need for sensor miniaturization to allow the use of smaller-class (and affordable) UAS platforms [6] [31] [7] [1] [5] [21] [22].

In this modern day technology, developments in surveying and mapping equipment have now evolved to the point where the traditional instruments that were used until about the 1960s or 1970s, the likes of the vernier and transit theodolites, dumpy and tilting levels, linen and steel tapes etc. have now been almost completely replaced by an array of new "high-tech" instruments [3] [22] [5] [9] [11]. These include electronic total station instruments, which can be used to automatically measure and record horizontal and vertical distances, and horizontal and vertical angles among other capabilities; Global Navigation Satellite Systems (GNSS) such as the Global Positioning, System (GPS) that can provide precise location information for virtually any type of survey. Laser-scanning instruments combine automatic distance and angle measurements to compute dense grids of coordinated points. At the inception of using GNSS receivers, it was taught we have gotten to the pinnacle of modern technology in surveying and mapping until recently when the use of Unmanned Aerial Vehicle (UAV) technology was introduced to Surveying and Mapping exercises [3] [22] [5] [11] [18] [19] [17] [24].

Unmanned Aircraft Systems (UAS), also referred to as drones, unmanned aerial vehicles (UAVs), and remotely piloted aircraft (RPA), have a lengthy military pedigree that reflects their long-recognized potential in supporting warfare efforts. Although their highly publicized missions may convey the impression that UAS are a recent technological innovation, the use of unmanned flight pre-dates human-piloted flight. Aerial bombardment of Venice in 1849 was undertaken (albeit ineffectively) by unmanned hot-air balloons [5]

An unmanned aerial vehicle (UAV) like receivers in GPS is just a component of a system called Unmanned Aircraft System (UAS); which include a UAV, a ground-based controller, and a system of communications between the two. UAV is therefore a high-tech drones or aircraft without a human pilot aboard. The flight of UAVs may operate with various degrees of autonomy: either under remote control by a human operator or autonomously by onboard computers [2] [4] [26] [6] [31] [20].

The word 'drone' (Dynamic Remotely Operated Navigation Equipment) has been commonly used to mean UAV. Such act is misleading because high levels of technology were not required in DRONES operation. The existence of drone was dated back to 1800 when the Austrian army used balloons filled with bombs to attack Venice. However, these drones have no advanced piloting controls to predetermine their destination. American Army also used drones in 1900s when they were used for training purposes. By 1930s, there was technological advancement in drone operation when more of UAV emerged during World War II. They were used both to train antiaircraft gunners and to fly attack missions. Nazi Germany produced and used various UAV aircraft during the war [6] [31] [14] [22].

United States Air-Force deployed UAV during Vietnam War between 1959 and 1964 but did not disclose the usage until later in 1973. Other nations such as Israel in 1973 (Yom Kippur War) and between 1967 (War of Attrition) deployed UAV against Syrian defense.

However, the use of UAVs were limited to military deployment with little commercial usage until in 2013 when the Amazon CEO, Jeff Bezos announced that they were testing the use of drones as a method of delivery. Since then, the commercial sector has been abuzz with the endless opportunities UAVs can create. Classification of UAS platforms for civil scientific uses has generally followed existing military descriptions of the platforms based upon characteristics such as size, flight endurance, and capabilities among others [5] [19] [23].

AIM AND OBJECTIVES OF THE STUDY

This paper is aimed at showcasing the importance of applying UAS in Mapping, Monitoring and controlling of crimes within the study area.

The objectives set and painstakingly pursued in order to achieve the aim of the study include Design of a well-structured relational database, Geometric and attribute data acquisition, Database creation through integration of different datasets within the environment, Spatial analyses and Information presentation.

SCOPE OF THE STUDY

The scope of the study includes planning, capturing of imagery of the study area with Phantom 4 Pro UAV (Quadcopter), Downloading of the images and processing including Georeferencing with Ground Control Points (GCP) using Agisoft Photoscan Professional software to acquire the applicable products such as the mosaicked image and Orthophoto of the study area, Vectorization of all the necessary details on the geo-referenced imagery for analyzing locations prone to insecurity, Physical design of the database, Spatial analyses and query generation which include the production of customized maps at appropriate scales. [5] [28] [1] [14].

Figure 1: Phantom 4 Pro, Image courtesy DJI Company and Federal School of Surveying, Oyo

Figure 2: Aeryon Scout VTOL UAS. Image courtesy Aeryon Labs, Inc. (Tricopter)

Figure 3: Aeryon Scout VTOL UAS. Image courtesy Aeryon Labs, Inc. (Quadcopter)

LOCATION OF THE STUDY AREA

The study area is Federal School of Surveying, Oyo. It is along Oyo Ogbomoso road in Oyo East Local Government Area, Oyo State, Nigeria. It lies approximately between Latitudes 07 50' 24".02 N, 07 50' 42".45 N and Longitudes 03 56' 25".21 E, 03 57' 53".53 E.

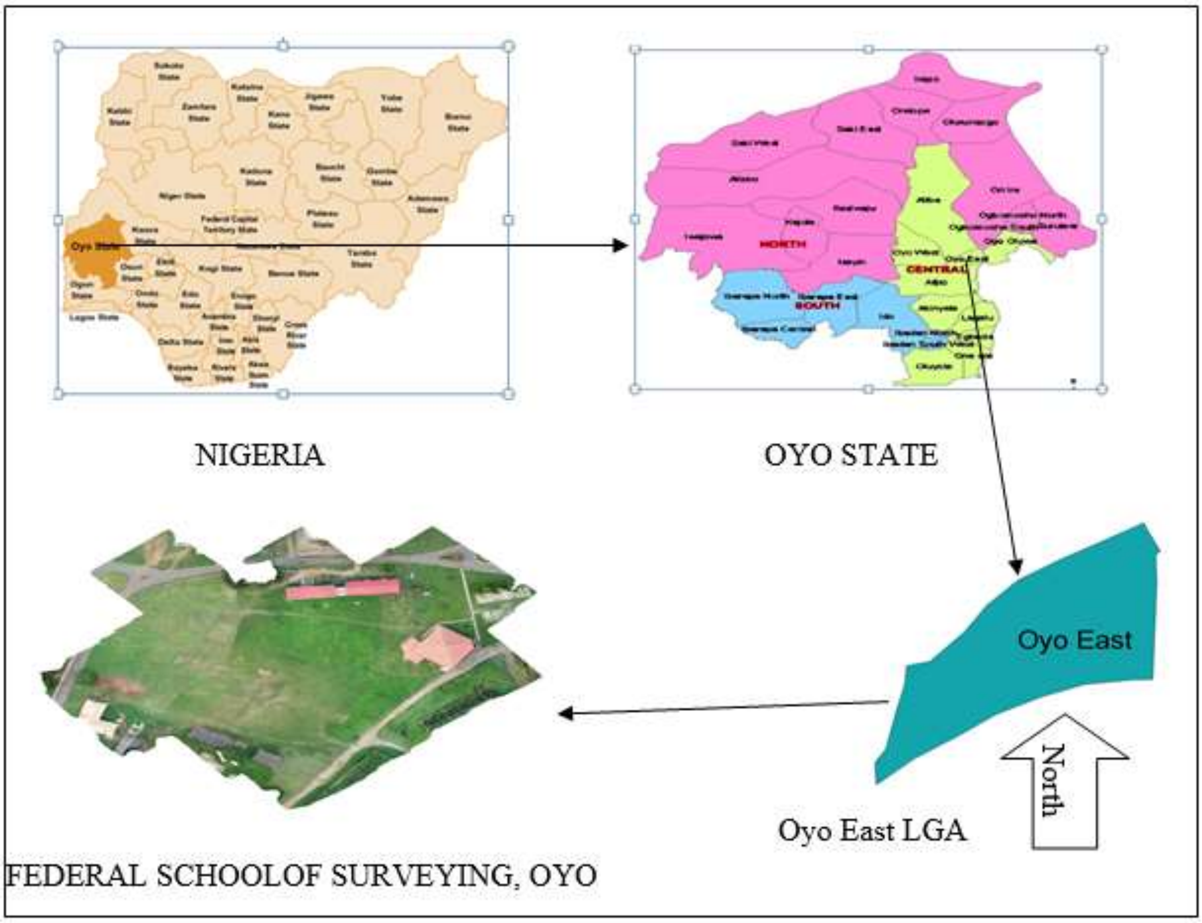

Figure 4: Study area

FLIGHT PLANNING AND DATA COLLECTION

Data was captured on 24th September, 2018 and the Flight Planning of the study area just like in general photogrammetry approach was done by DJI GO, it has the goggle map and imagery tiles embedded which shows the locations by search or navigation and this was used to define the flight boundary which otherwise brings a default flight lines including the front and side overlap values which was later changed to desired values and this planning was sent and uploaded to the drone [31] [2] [20] [4] [26] [6]. Due to availability of some communication masts within the premises of the institution, altitude of 60m was selected for the flying height, front/side lap is 60/70% respectively and the drone flew according to the plan. It took approximately 20 minutes to cover the entire study area with a total number of 55 images planned on ten (10) main lines on an average speed of 2.2m/s and the achieved resolution is 1.8cm/pixel. See figure 5 for sample camera locations and image overlaps.

Though, a suitable leveled ground was selected within the premises of the institution for save vertical takeoff and landing of the autonomous flight (Figure 1) and having considered all the necessary precautions and flight controls, the UAV was flown as earlier discussed.

Also, locations within the study area prone to certain security challenges were captured using hand-held GPS with same coordinate configuration as in that of the drone (WGS84 Datum -UTM31). The selected areas were prone to smoking, stealing, fighting, hooliganism etc.

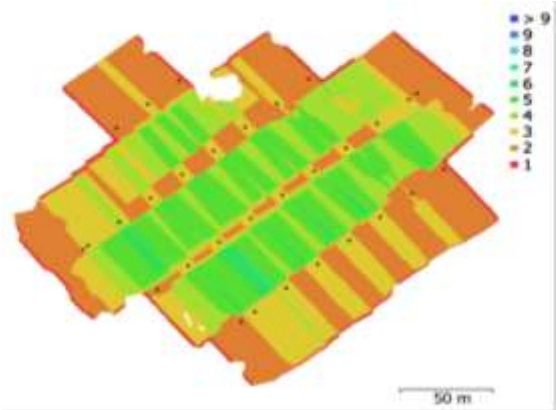

Figure 5: Camera locations and image overlap

Figure 3: DJI Phantom 4 Pro (Complete UAS)

DATA PROCESSING

Two software were used for this purpose and they include Agisoft photoscan professional and ArcGIS for Desktop 10.1. The captured image using the drone was downloaded and added in Agisoft photoscan professional from DJI for further processing, above all for a mosaic building to generate the Orthophoto (Georeferenced Imagery), it is of note that the Ground Control Points (GCP) were used during processing for better accuracy of the imagery [3] [22]. The mosaic imagery was imported into ARCGIS10.1 environment for visualization and further processing. The boundary of the study area in shapefile was used to clip the entire imagery to extract the desired study area. The hand-held GPS data for the crime areas was downloaded and imported into the same ArcGIS10.1 environment and overlaid on the image. The locations were symbolized as point features on the imagery with a Geodatabase created and all the attribute data were attached to respective crime spots as obtained during social survey. Some features were vectorised as seen on the imagery (Figure 7-10).

A map was produced showing locations of each feature and locations of some common crimes within the study area. The common crimes were stealing, smoking, fighting and gangsterism.

RESULTS AND INTERPRETATION

Following the visual interpretations and vectorization of notable and interested features on the imagery, the following were extracted showing the roads and the buildings which include (Offices, Student hostels and Lecture halls).

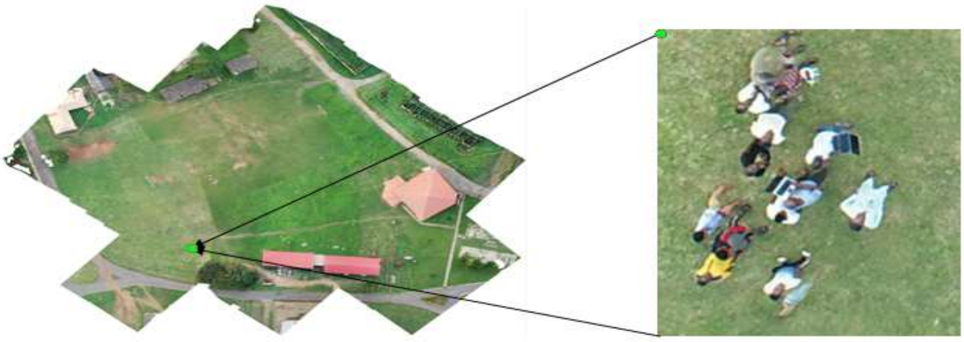

Figure 6: Part of the Imagery showing the students working on the field at a very high resolution even at 60m Altitude.

The following figures show crime locations within students' area.

Figure 7: Locations where fighting among students usually took place (Hostel Area) in Yellow

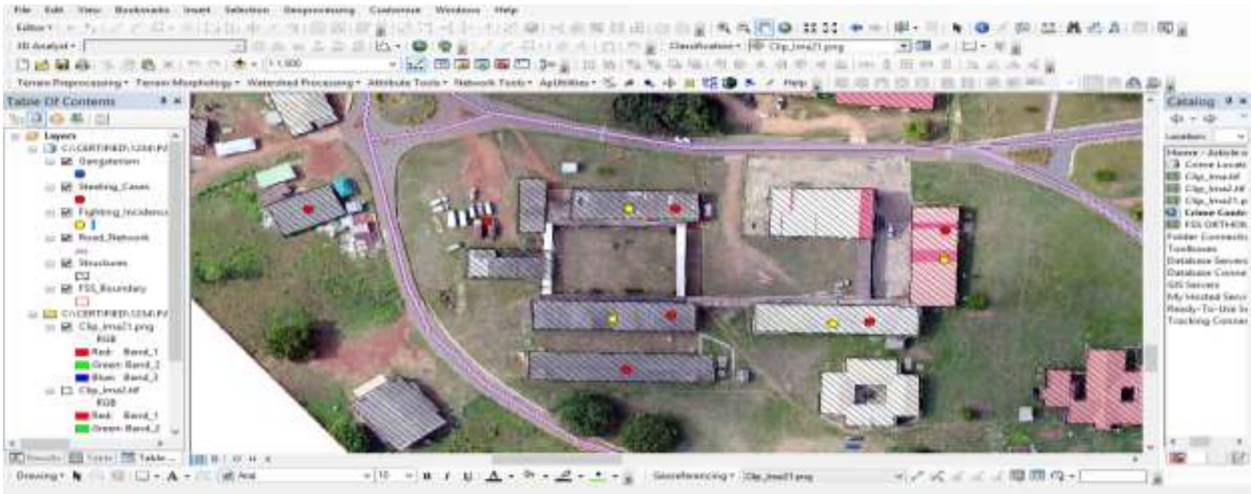

Figure 8: Locations where almost all the classes of crime took place among students (Lecture Hall Area) Gangstarism in Blue, Stealing in Red and Fighting in Yellow

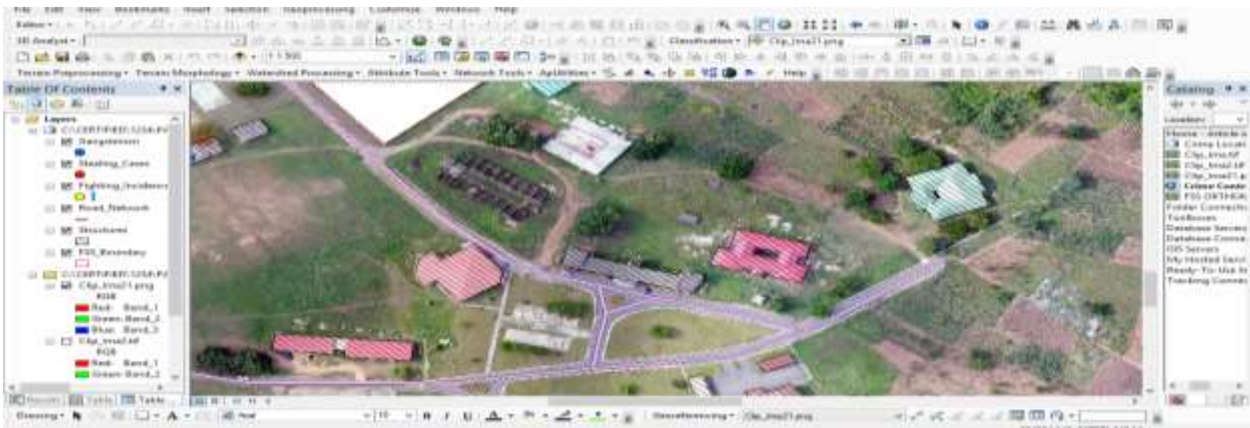

Figure 9: Locations where no case of crime has been recorded (Office Area)

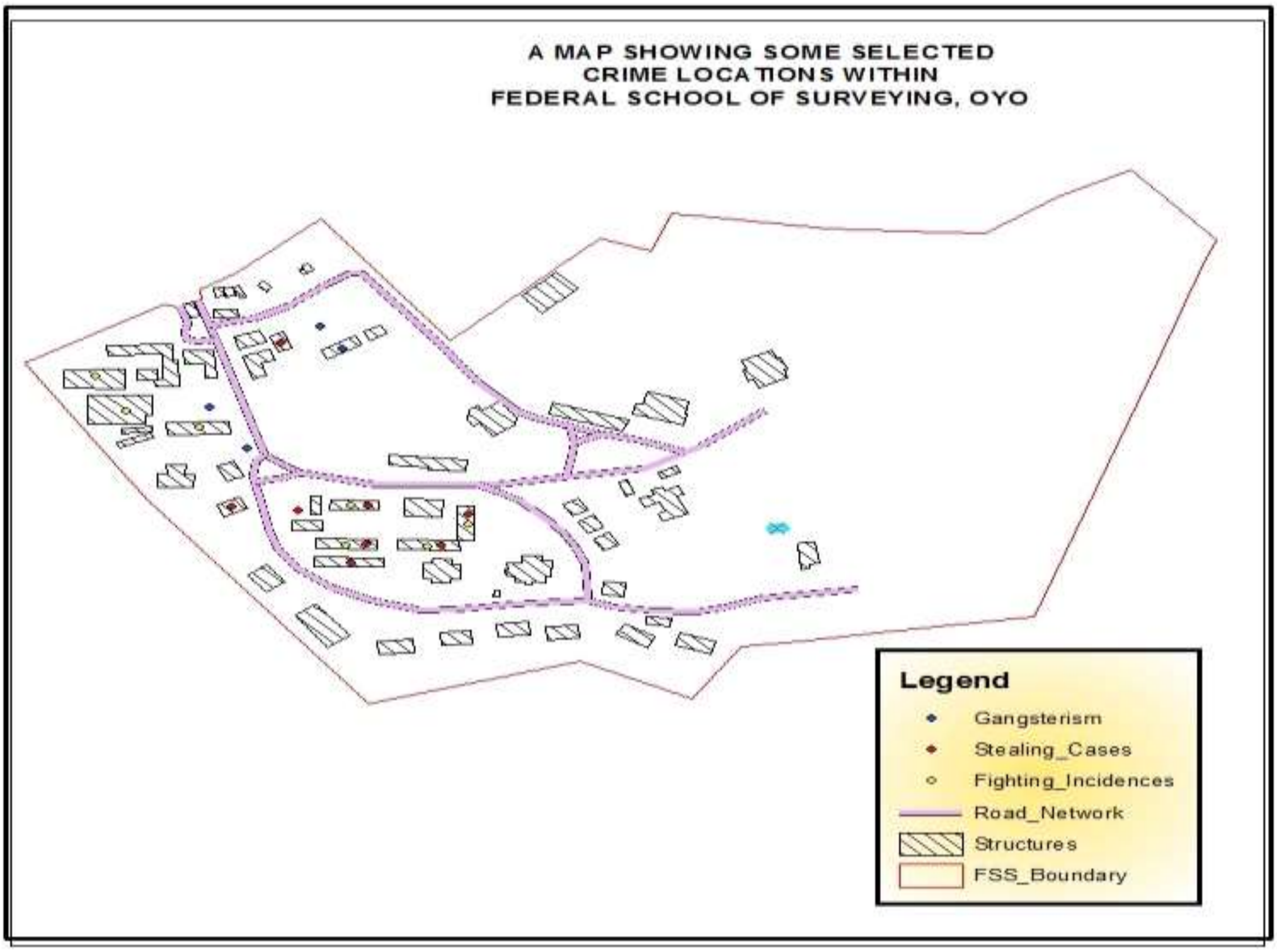

Figure 10: Composite map of the study area showing different crime locations

COMMENTS
From the figures above, it shows that student's area was prone to cases of crimes recorded so far within the study area. The imagery captured using UAV at a very high resolution showed significantly human being, vehicles and other tiny objects which imagery from satellite could not afford to provide as seen in (figure 4). The use of Drone/UAV made it possible to carry out surveillance around the hotspot areas for crime activities and can be used as combat vehicles for dropping tear gas and other security preventing gadgets in the cases of fight outbreaks between students and other incidents that could call for emergency.

CONCLUSION
Crime and all other kinds of insecurity can be monitored and controlled by a middle-class UAV which is equipped with a high resolution camera recording only in the visible spectral bands of the electromagnetic energy. These UAVs provides data with a very high spatial resolution at acceptable costs and it can be used to combat insecurity, as in this case. This device is now affordable even by individuals and can be used for such productive mapping jobs as seen here rather than the common idea of cinematography and videography application as most people under used them. Though, Ethical concerns and UAV-related accidents have driven nations to regulate the use of UAVs depending on countries and regions.

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