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Application of UAV's in Agriculture: Nigeria's Case

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Abstract: Precision Farming has been described as a new approach to farming whereby information technology is introduced into the whole production process so as to increase yield, save time and cost and improve the overall economic outlook of a nation. Information has been found to be one of the key requirements to achieve this great feat. Unmanned Aerial Vehicles (UAV's) have been used over the years mostly in military applications. Recently, these low cost, low maintenance vehicles have been utilized in precision agriculture from overall monitoring of the crop field to spraying of pesticides and fertilizer. In this research, the need to adopt UAV's in the context of Nigerian farmers most of whom are small scale in nature is presented. Potential areas of application such as in the field of crop monitoring and spraying system are analyzed.

Keywords: Nigeria, Precision Farming, UAV, Crop Monitoring, Spraying Systems

I. INTRODUCTION

Over 70% of the Nigerian people depend directly or indirectly on agriculture. Agriculture is therefore vital to the Nigerian economy due to the role it plays in providing employment, income, food and raw materials for several industries in the country [1]. Nigeria currently has a population of around 186 million people, while also having one of the youngest youth populations worldwide [2]. The economy of Nigeria relies heavily on oil exports making the country's GDP dependent on global oil prices. The country witnessed an 8% GDP growth in 2006 and -1.5% (recession) in 2016 in the aftermath of the global oil price crash of 2015. Despite the over-reliance of economy on oil exports, agriculture remains the bedrock of the Nigerian economy where 36.5% of the labor force is engaged thus being a major source of livelihood the population. The agricultural sector continues to constitute a significant portion of the economy at 21% even when the economy contracted [3]. Amongst the farming demography, 88% of the farmers are considered small scale that depends on a range of crops, livestock and fishes for survival [2]. A large proportion of these small scale farmers live below the poverty line. One of the ways of uplifting these farmers is be addressing several of the problems being faced such as: increasing the amount of irrigated land as currently less than 2% of crop land is irrigated, provision of mechanized form of farming and application inexpensive technology such as Unmanned Aerial Vehicle also known as a drone.

II. UNMANNED AERIAL VEHICLE

UAV is an expensive alternative deployed in sensing technology and data analysis [4]. A quad copter is a type of UAV which has four rotors.

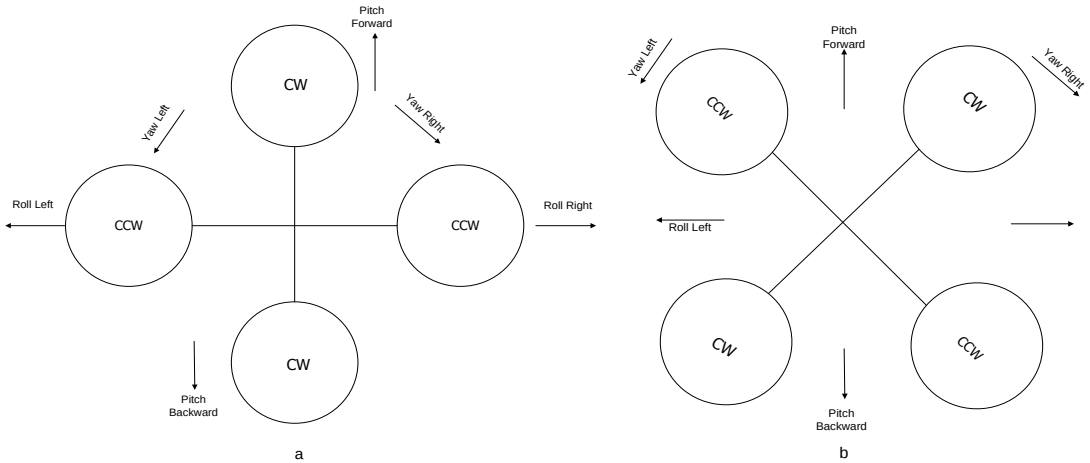

Fig 1: Quad copter Configurations (a) Plus Configuration (b) Cross Configuration [5]

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The lift of quad copter is generated by the four rotors, two opposite rotors are turn in Clockwise Direction (CW) and the other two in Counter Clockwise Direction (CCW)Remote sensing involves using electromagnetic energy to determine the properties of targeted object from a distance . The quad copter movement around the axis could be forward and backward, roll (left and right), and yaw (clockwise and counter clockwise). Furthermore, the configuration could be plus (+) model and cross (X) model [5]. Cross (X) model is the most stable amongst the two thus the most widely used [6].

The UAV consists of several components. The flight controller is the main board which has the most advanced firmware and is responsible for the actual flight. It is built using a microcontroller that then communicates with the four brushless motors (BLDC). The BLDC motors are connected to the rotors in the direction of the chosen UAV configuration model. The motors are controlled using Electronic Speed Controllers (ESC).
There are several advantages for utilizing UAV's in agricultural practices [7]. Some of the pros are as follows:

- Ability to take off from virtually any terrain without any preparatory engineering work
- Shorter and cheaper training of operators of UAV operators unlike manned aircraft that requires years of training and re training.
- Lower cost as compared to manned aircraft.
- Ability to provide information in real time
- Ability to work in extreme circumstance such as: extreme weather conditions, chemical and radiation pollution etc.
- UAV's do not require specifically designed airfield for their operation
- No danger of pilot death
- More accurate spraying radius.
- Very low cost of operation as compared to manned aircraft.

III. AREAS OF APPLICATION

There are broadly two areas of UAV application in agriculture: crop monitoring and sprinkling system [8][9]. UAV's are equipped with cameras and sensors for the purpose of crop monitoring while sprinklers are attached to UAV's when a sprinkling system is desired. Over the years, UAV's have been used several military applications, the first application of UAV's was in Japan by Yamaha where Yamaha RMAX was introduced for agricultural pest control and field monitoring of crops [9].

A. Sprinkling System: Precision farming is a new concept in agricultural production that manages all facets of agriculture by incorporating the field of information technology so as to better manage the natural resources while also realizing a sustainable agricultural development model [10]. The three key elements of precision farming are: Information, Technology and Management. Information is the most important aspect of the overall production process, information on crop characteristics, soil properties, fertility requirements and weed population [11]. The sprinkling system should be applied after information that has to do with the application is sought.

The sprinkling system can be divided into two components; the sprinkling system and the controller. The spraying system consists of the spraying material which can be pesticide or fertilizer and a nozzle for spraying. The second component is the controller which is used to activate the nozzle of the sprayer. A pressure pump which is a component of sprinkler system pressurizes the pesticide/fertilizer to flow through the nozzle while the motor driver integrated circuit is used t0 pressure the pump as per requirement [5]. Figure 2 shows the block diagram of a UAV mounted sprayer.

In [5], a comprehensive review of several UAV mounted spraying systems was discussed. A summary of these finding is presented in table 1.

Table 1 Summary of UAV Mounted Systems [5]

Source	Sprinkling Speed	Nozzle Type
[13]	Depends on communication between UAV and WSN	-
[14]	4.45m/sec	-
[15]	0.2MPa (Pressure)	Flat Fan
[16]	0.3MPa (Pressure)	Fan shaped (Electrostatics)
[17]	0.3-0.8 l/m	Flat-fan, Centrifugal and cone
[18]	1.25 l/min	Conical
[19]	850 ml/min	Electric centrifugal
[20]	850 ml/min	Rotary atomizer
[21]	0.2–1.0 MPa (Pressure)	Flat Fan

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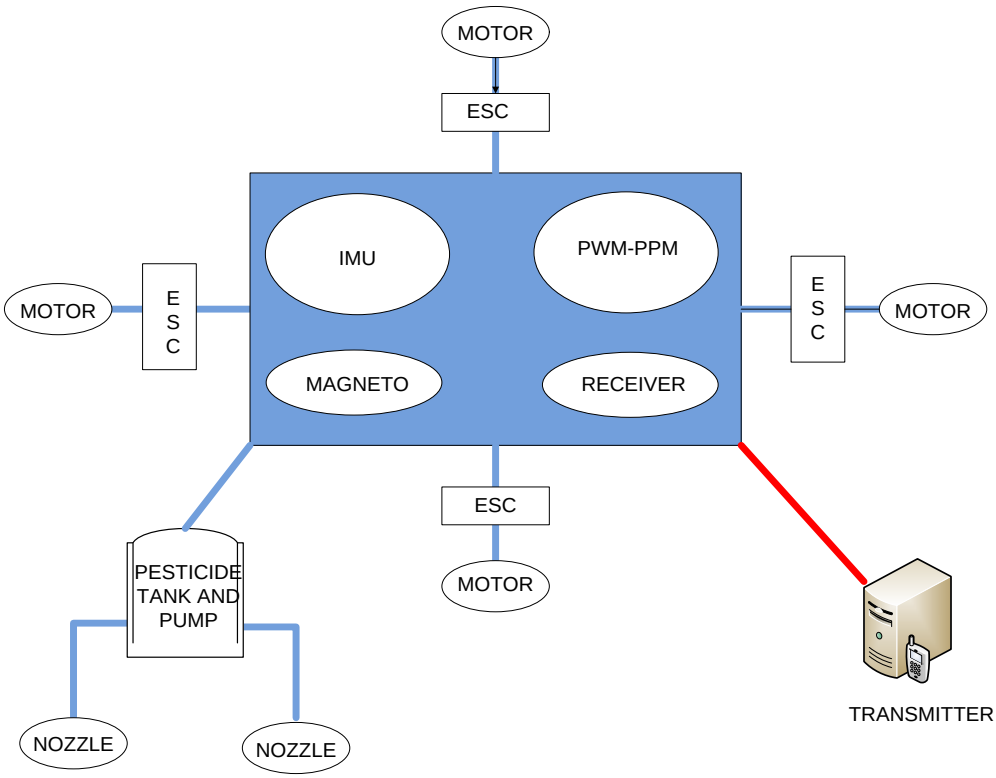

Fig 2: Quadcopter for pesticide spraying [12]

B. Crop Monitoring: Crop monitoring entails making several measurements on the local climatic conditions at different locations. To achieve this feat, several wireless sensors are designed in such a way to form a wireless sensor network for the sole purpose of data collection. The collected data is then relayed in real time to the control center where an informed decision will be made [22]. A UAV can cover several hectares during a single flight. For this purpose, thermal and multispectral cameras are mounted for the purpose of data capture and real time analysis [23]. The camera takes a picture per second stress it and then sends it to the ground station using telemetry. The pictures are captured in five visible bands with different wavelengths i.e. blue (wavelength 440-510nm), green (wavelength 520-590nm), red (wavelength 630-685nm), red edge (wavelength 690-730nm), near infrared (wavelength 760-850nm). The data coming from the multispectral camera through telemetry is then analyzed using the Geographical indicator Normalized Difference Vegetation Index (NDVI) which is given in equation one [24].

$$NDVI = \frac{R_{INR} - R_{RED}}{R_{INR} + R_{RED}} \quad (1)$$

Where R_{INR} is the reflectance of the near infrared band and R_{RED} reflectance of the red band.

From equation one, values will range from -1 to +1, values close to zero indicate no vegetation, white values close to +1 indicate high density of green leaves on the crop. Based on the provided information, a decision can be made on the next step to be taken.

IV. CONCLUSION

Over the last few decades, economies of countries that heavily depend on a single product (crude oil in most cases) as a source of foreign exchange have suffered tremendously. From Venezuela to Nigeria the story is similar. Agriculture is the highest employer of labor in Nigeria; with virtually untapped potential, current government policies have been geared towards developing that sector of the economy so as to reduce the dependence on oil exports. However, modern approach to farming has been lacking in virtually all sectors of production. Introduction of UAV's in agriculture can go a long way in improving the quality of produce, save time and cost and improve the economic outlook of the population.

Further research into development of UAV's in solving local problems in currently underway. Small scale farmers belonging to a cooperative are the target of this research.

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