A Review of Applications and Potential Applications of UAV

N. Muchiri, S. Kimathi

***Abstract*—** In this review paper, practical experiences of unmanned aerial vehicles (UAVs) in precision agriculture and remote sensing are explored. In two case studies, their use is compared with traditional aircraft or satellite based platforms and UAV provide better results in both cases and at lower cost. Based on this, other potential local uses of UAVs are highlighted that may help expedite their use locally and attract wide research, investment and better policy regulation for their application.

***Keywords*—** Agriculture Monitoring, Drones, Remote Sensing, potential applications.

I. Introduction

Unmanned Aerial Vehicles (UAVs) also known drones refers to aircraft which fly without a human operator onboard. They have recently found wide applications globally which include gaming, mapping, cartography, border patrol, inspection, search and rescue, fire detection, agricultural imaging, traffic monitoring and military applications they are being envisioned for wider applications with advancement of design technology. Locally, there is limited application of UAVs except in research, experimentations and in military primarily due to minimal exposure and prohibitive policies. This paper explores their current applications, uses, potential advances and alternative uses. This may help facilitate their use and attract wide research, investment and better policy regulation for their application locally.

II. Brief history

UAVs have developmental origin in military applications but as their capabilities expanded, civil sector UAVs and civil applications followed soon after. In 1986 UAVs were tested for monitoring forest fires in Montana, by 1994, UAVs such as Predator provided improved image resolution [1]. Recent research on potential civilian applications show that they can be applied in weather research, mineral exploration, coastal surveillance, and marine resources assessment, ice and snow assessment, soil moisture, wildlife census, animal tracking, invasive plant assessment and archeological site assessment [2] [3] [4]. UAV application in forestry has been tested with specific studies in forest resources assessment, forest fire monitoring, and forest fire recovery [5]. Additionally, tests have been conducted in agricultural monitoring in Hawaii where high speed digital photography was used to predict coffee bean ripeness.

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III. Applications in agriculture

UAVs are currently being applied by farmers in wide field analysis of crop behavior such as rice, maize and wheat where they scan through the field, take images and report abnormality [6]. This is an improvement of satellite based field assessment and offers more precise information and in most cases real time. Precision agriculture, PA is another area where UAVs have found applications, the general stages of PA practice being data collection, field variability mapping, decision making, and finally management practice. Their use aids in remote sensing which is involved in the first three of these stages [7] [8]. The real time images/maps are obtained during the process of decision making, thus enabling mapping of field variability using remotely sensed imagery.

In PA, crop parameter monitoring during the growing season is done using satellite images and aerial photos [7], their images are improved by coupling this with high-resolution airborne remote sensing system [8]. It is found that their application is limited by poor revisiting times and/or coarse spatial resolutions. An improvement in this is by the use of manned airborne platforms though limited also by high operational complexity, costs and lengthy delivery of products [9]. These have been solved by the use of UAVs in Low Altitude Remote Sensing (LARS) system, a concept of acquiring earth surface images at a low altitude [10], which is providing an alternative platform for PA. Key advantages for this is that it has ultra-high spatial resolution, relatively low operational costs, and the near real-time image acquisition.

A. Agriculture application Case 1

In a research in Quantalab, Instituto de Agricultura Sostenible (IAS), remote sensing sensors were placed on (UAVs) provided low-cost approaches to meet the critical requirements of spatial, spectral, and temporal resolutions [11]. In this application, UAV was coupled with a lightweight six-band multispectral camera and thermal imaging sensors and gave results which showed the ability to generate quantitative remote sensing products by means of a helicopter-based UAV equipped with inexpensive thermal and narrowband multispectral imaging sensors.

Their system was developed based on modified model aircraft Quanta-H (fig1), and Quanta-G (fig2) equipped with

an autopilot which allows fully autonomous navigation following a user-defined flight plan. Differential GPS corrections are retrieved from the closest GPS reference station in real time. The flight plan is created computer application on user defined region of interest, flight direction, altitude and focal length of the camera.

Quanta-H is a rotary wing UAV with 29 cm^3 petrol engine and can carry up to 7kg of load flying at a maximum speed of 30 km/h. The main advantage of this platform is the vertical takeoff and landing capabilities. However its low speed is a limitation but make it ideal for small experimental plots.

Fig.1 Modified model Helicopter (Quantalab, Spain)

Quanta-G is a fixed wing UAV of 3.2m wingspan has a 58 cm^3 petrol engine (fig 2). The endurance is 30 minutes flying at 90km/h and can take a load of up to 5.5kg. Despite the larger yield due to the higher speed and endurance, the main disadvantage is that it requires a runway for take-off and landing.

Fig.2 Quanta-G fixed wing UAV (Quantalab, Spain)

UAVs provided quick turnaround times together with lower operation costs and complexity.

It was found that at high turnaround times, make UAVs particularly suitable for applications such as precision farming and irrigation scheduling, where time-critical management is required. Comparing this with the manned air systems the image products of leaf area index, chlorophyll content and water stress detection from PRI index and canopy temperature were produced and validated as better results than those obtained by traditional manned airborne sensors [12]. The works by Department of Spatial Sciences, Curtin University of Technology (Perth) shows a more advanced application of UAV in agriculture where UAV was coupled with Digital Multi-Spectral Imagery (DMSI) and applied for mapping and monitoring crop and soil variability [8].

IV. Application in Remote Sensing

Remote sensing is the science of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation [13]. Using various sensors, data can be collected that may be analyzed to obtain information about the objects, areas, or phenomena being investigated. The remotely collected data can be of many forms, including variations in force distributions, acoustic wave distributions, or electromagnetic energy distributions. Unmanned aerial vehicles (UAVs) are becoming popular as tools for remote sensing applications [14]. Recent developments in the vehicles themselves and associated sensing systems make these platforms increasingly attractive to the geoscience community. UAV platforms and imaging and sensing systems that are adaptable to these platforms facilitate unique capabilities in Earth observation for both research and operational monitoring purposes.

A. Remote Sensing application: case2

This is based on research Department of Geodetic Engineering, Gadjah Mada University (Indonesia), where UAVs applications were illustrated [15]. The applications are briefly described below.

a) Application in aerial survey activities to support calculation or assessment of wood or asset stock. So, the individual tree structures has to be seen clearly, and canopy diameter can be measured from the imagery.
b) Application for calculating area of parcel in paddy field areas where areas show that there are no significant differences between terrestrial and aerial mapping product.
c) Application in Palm-Oil Plantation to support calculation of stand per Hectare (SPH) of individual palm trees.
d) Application in Sugar Cane Plantation to support taxation calculation for sugar cane Asset. It provided 3D information to determine volumetric. The High resolution provides images to inform of the density of vegetation and weeds.

Another case in remote sensing is illustrated in works of USDA-ARS, Jornada Experimental Range where UAVs were applied in remote sensing for rangeland assessment, monitoring, and management [16]. Where UAV technology was applied to augment and improve rangeland management activities. They offered better imagery mainly due to their simplicity, relative low cost, reliability, and operational flexibility.

These cases show practical experiences of UAVs in remote sensing and support of cost effective precision agriculture mapping. Compared with more traditional aircraft or satellite based platforms, the UAV fills a previously unoccupied niche due to the unique characteristics of data it is able to capture.

Its low operating altitude allows for the generation of ultra-high spatial resolution data over relatively small spatial extents [17].

V. Other applications

A. Long Range Environmental Monitoring

In meteorological surveillance, UAVs are currently being used in weather research units such as in the Australian Bureau of Meteorology, Taiwan's National Science Council and Central Weather Bureau, the US Department Energy [2].

B. Monitoring Agriculture (spraying UAV systems)

In Japan, Yamaha Industrial Unmanned Helicopters are small commercial viable helicopter UAVs to meet requirements for crop dusting and spraying [18]. Yamaha Aero Robot "R-50," is an industrial-use unmanned helicopter with a 20 kg effective load capacity. In recent years the Japanese farming industry has been plagued with problems like the aging of the work force and a lack of younger generation successors. In light of this situation, the Yamaha industrial-use unmanned helicopters have become the focus of attention as economical, environment-friendly next-generation agriculture devices that are now being used primarily for crop dusting.

C. Coastal Surveillance

UAVs are being applied in USA and Australian coastline to monitor shipping, fishing and other coastal activities [2].

VI. Potential applications and market

In terms of value, the global Unmanned Aerial Vehicles Market is estimated to be USD 10.1 Billion in 2016 and is expected to show a robust growth to reach USD 14.9 Billion by 2020, thereby registering a CAGR of 8.12%, from 2015-2020 [19].

A. Delivery

Drones could be used for delivery of goods to customers without having to send a driver. Amazon has announced a drone delivery initiative while other companies have UAV-based food delivery such as pizza delivery drone [20].

B. Internet service

The solar-drones, aims to provide wireless internet to remote parts of the world. Their use is currently being explored independently by Facebook ™ and Google where the drone has a potential to stay airborne for five years and would act as movable wireless access points [21].

C. Other potential applications

There are many other potential uses of UAV. Some of the areas under research include.

- Mineral Exploration and Exploitation.
- Media resources;
- Environmental control and monitoring;
- Telecommunications;
- Crop and aquaculture farm monitoring;
- Unexploded ordnance detection.

VII. Conclusion

The above cases show practical experiences of UAVs in remote sensing and support of cost effective precision agriculture mapping. Compared with more traditional aircraft or satellite based platforms, the UAV fills a previously unoccupied niche due to the unique characteristics of data it is able to capture. Its low operating altitude allows for the generation of ultra-high spatial resolution data over relatively small spatial extents [17].

The commercial applications of UAVs in photography, wildlife research & survey, agriculture, surveillance, surveying, and mapping would offer great opportunities for growth in the near future. The Unmanned Aerial Vehicles Market is driven by the reduced risks associated with the use of UAVs, increasing demand for the UAVs in the commercial and defense sectors, and better technological innovations that have created a demand for the UAVs in performing complex operations with reduction in the need for human intervention.

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