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POSSIBILITIES FOR THE USE OF UNMANNED AERIAL VEHICLE IN AGRICULTURE AND FORESTRY

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Abstract: Unmanned aerial vehicles, known as "drone" / "UAVs" / "airRobots"/ "RPAs" / etc., are flying vehicles remote controlled by a specialized operator, through a ground control stations (GCS), consisting of a laptop, a navigation software and radio modems. The paper contents a brief presentation of the current status and some advantages in using UAV systems, as a feasible alternative or as a complementary method for various agricultural and environmental applications. Worldwide, in precision agriculture, UAVs are already used for the following applications with positive results: (i) field monitoring to find areas with pest attacks on crops; (ii) local application of plant protection treatments, with quantities reduced to attack surfaces; (iii) determination of plant water stress in order to optimize water consumption; (iv) production forecasting; (v) assessment of crop damage or calamity etc. The paper also includes an overview of the structural characteristics and parameters of an UAV of multi-rotor type, equipped with various sensors which was developed and tested in Romania for crops and forestry monitoring, ready to use in remote sensing scientific programs (NDVI calculation, achievement of aerial photographs and maps etc.), the Romanian market starting to be receptive to this new technology.

Key words: *UAV, remote sensing, precision agriculture, forestry*

INTRODUCTION

The most recent study on UAV (UAV Market research report 2015) estimated a market value of over 10.1 billion in 2015, with an increasing trend to 14.9 billion USD by 2020 (http://www.marketsandmarkets.com/). Designed and used initially for military applications, these vehicles without human pilot on board became available as technology and prices for various civilian applications in the last 2-3 years (e.g. precision agriculture, precision forestry aerial maps, calculation on volume excavated from surface quarries, flood maps, aerial photographs and footage, surveillance and fire fighting, agricultural crops and forests monitoring to prevent theft, studies of the atmosphere / environment, etc.).

Although UAVs are an emerging technology, they are rapidly adopted in agriculture, since this sector is expected to benefit from their use, 10 times as much as other industries.

The international organisation *'The Association for Unmanned Vehicle Systems International*' predicts the fact that the use of UAVs in agriculture will have a great impact, estimating an income of 75 billion dollars by 2025.

The paper outlines the current status and the advantages of using UAV systems in various agricultural and environmental applications worldwide.

Also this paper aims to promote the use of such systems at the national level by presenting the structural characteristics and parameters of a UAV system, equipped with colour and NIR cameras that have been developed and tested in Romania.

MATERIAL AND METHODS

The bibliographic study contains a brief overview of the name, concept and terms, UAVs progress and state of the art in the world but also in Romanian research, for which the use of such technology is in its early stages.

HeadHunter system presented in this paper has been designed, tested and manufactured in Romania, using the latest/advanced equipment and technologies. It was designed specifically for use under harsh conditions (landings in crops over uneven ground without the need for special runway for takeoff and landing).

RESULTS AND DISCUSSIONS

Because of the recent wide variety of UAV applications, terminology has become a recent hot topic for the Unmanned Aerial Vehicle System Association (http://www.uavs.org).

An *unmanned aerial vehicle* (UAV), commonly known as a *drone* and also referred to as a *remotely piloted aircraft* (RPA) by the International Civil Aviation Organization (ICAO), is an aircraft without human pilot aboard (http://www.icao.int). Its flight is controlled either autonomously by onboard computers or by the remote control by a pilot on the ground or in another vehicle. UAVs are usually deployed for military and special operation applications, but also used in an increasing number of civil applications, such as fire fighting, crowd control, crop management or livestock monitoring, mapping and non-military security work, such as infrastructure monitoring, inspection of wind turbine, power line or pipelines, etc. Thanks to their ability to replace the human beings, the UAV are preferred for missions that are too "dull", "dirty" or "dangerous" for manned aircraft (Cook, 2007; http://www.icao.int; http://www.uavs.org; http://www.louzettler.com).

There are numerous advantages to the use of small UAV systems to acquire agricultural and environmental imagery, with two primary benefits: the cost of operation and availability. Scientists and farmers can purchase aerial imagery from various sources, such as satellite data, which is usually not current and of a relatively low resolution. Imagery created using light aircraft may have a higher resolution and may be cheaper and more up-to-date, but it is still relatively expensive per hectare, in comparison with the use of small UAV systems. There is the potential to use the UAV system in the field in order to achieve very high resolution imagery at a fraction of the cost of satellite or light aircraft data (Haarbrink, 2011; Sugiura et al., 2005). Compared to standard airborne aerial surveys, UAVs are much more flexible and weather independent. As a result, UAV surveys will pave the way for obtaining affordable, current and accurate geo-information.

Precision agriculture (PA)/satellite farming/ site specific crop management (SSCM) is a farming management concept based on observing, measuring and responding to inter and intra-field variability in crops. Crop variability typically has both a spatial and a temporal component which makes statistical treatments quite necessary. Another proposed name for PA was "site-specific ag" because farmers are able to manage large fields as though they are a group of small fields. This reduces the misapplication of products and important savings are expected in terms of chemical products, water and labor. The milestone of PA research will be the ability to define a Decision Support System (DSS) for farm management with the goal of optimizing returns on inputs while preserving resources (http://www.europarl.europa.eu; https://soilsmatter.wordpress.com/; Bouma & Hansen, 1999; McBratney et al., 2005).

The combination of UAVs and multi-spectral image processing may be the next step in precision agriculture, the basic concept behind being very simple: the healthier a plant is, the more chlorophyll it produces; the more chlorophyll a plant has, the more green light it

reflects (https://www.morningagclips.com; https://www.michfb.com). With these multi-spectral images and a specialized program to generate maps, researchers will be able to get an image of the attacked area in the field. Thus maps, usually named "precision maps" are an extremely useful tools, allows a field monitoring to find areas with diseases, insects or weather damage, minerals deficiency, irrigation lapses, soil erosion etc. The high resolution images show exactly where to take action, saving time and expense of treating a larger area. UAV technology helps to more accurately and efficiently scout via remote sensing and may detect problems that are invisible to an observer standing on the ground due to the oblique angle of view, saving valuable time in critical crop conditions. (http://www.farms.com/precision-agriculture/;https://www.michfb.com; http://dronelife.com).

At present the use of UAVs in agriculture and forestry have a large variety of plant research, crop-protection and crop-production applications (Colomina & Molina, 2014; Costa et al., 2012; McBratney et al., 2005; https://www.microdrones.com; http://www.europarl.europa.eu; www.vision-systems.com; www.air-vid.com) as follows:

A. For agricultural research:

- Differentiation between multiple stressors of the crop status (mineral deficiency, biotic factors as pest or diseases etc.) through development of the "spectral signature" of crop pests and diseases in crops from the multi-spectral images taken from the vegetative (Near-InfaRed) images.
- Detection of diseases in plants before they become physically visible.
- Monitoring the condition of the fields throughout the growing season.
- Evaluation of crop conditions and variable rate technology.
- Invasive species and diseased areas location.
- Field trial analysis.
- Irrigation and other structural systems surveillances.
- Assessment of environmental impact and wildlife habitat etc.

B. For agricultural producers:

- Collecting data about their farms in the large area over which farms are spread within a very small amount of time allowing them to quickly make important decisions in the field.
- Disease Detection and Mitigation.
- Parasite Monitoring.
- Moisture Monitoring.
- Crop Growth Monitoring.
- Disease Outbreak Tracking.
- Weed Infestation Monitoring.
- Soil Erosion Monitoring.
- Creating an up-to- date digital map of the field.
- Minimizing the input (fuel, fertilizer, water for irrigation) according to the needs of crops in a particular field.
- Pesticides treatments localised to the initial area of concern.
- Optimization of production related costs.
- Increasing yield and preventing quality damage induced by pests.
- Yield forecasting.
- Harvest optimisation etc.

C. In Forestry:

- Biomass estimation.

- Forest health monitoring.
- Disease detection.

D. For authorities and insurance companies:

- Preventing loaning of fraud producers.
- Claims adjustments and avoiding risks when insuring agricultural producers.

UAV System 'HeadHunter' multi rotor UAV (referred further as 'HHPA' UAV) is a custom made solution for Precision Agriculture program development. Foldable, for easy transportation, it looks like a miniature helicopter with four propellers, which allow it to take off and land vertically (figure 1).

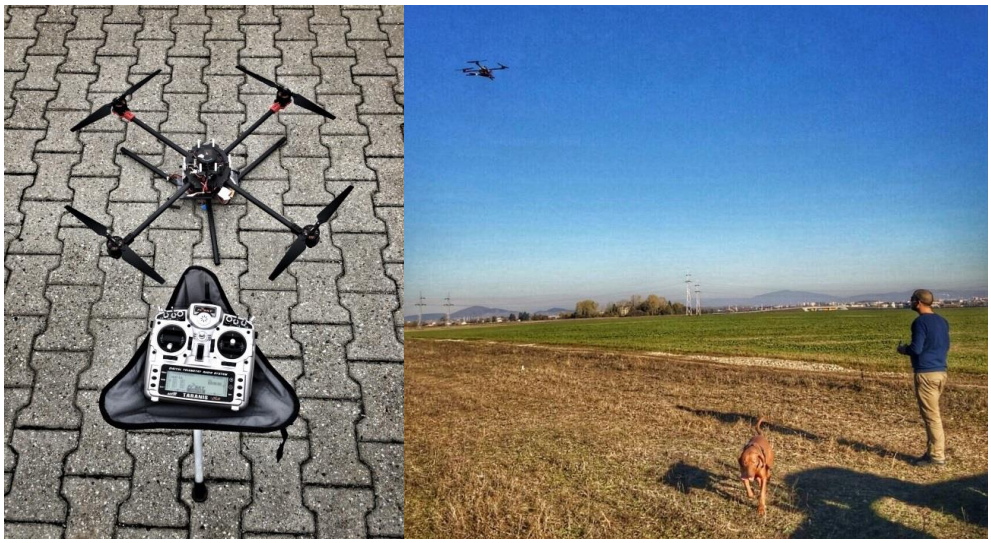

Figure 1. HeadHunter' multi rotor UAV

The 'HHPA' UAV has an open architecture, in order to be upgraded and to change the sensors at request. The main characteristics of the system are summarized in Figure 2.

Specifications:
Dimensions:
- Opened: 80x80x35 cm
- Folded: 80x20x25cm

MTOW: 6 kg (empty weight + battery + payload)
4000-10000mAh, 6S/22V battery (650g-1400g)
Charger (220V/wall socket+12V car adapter)

Performances:
- endurance: up to 30 minutes, depending on payload, batteries, wind status and flight style,
- flight range: up to 2 km (can be extended at request),
- max flight ceiling – 500 m,
- service ceiling: 50-100 m usual,
- waypoints navigation for accurate maps,
- payload: up to 2 kg (excepting the battery).

Flight limitations:
- wind speed up to 25 km/h,
- no rain, no snow, air temperature till minus 10 Celsius degrees.

Figure 2. HeadHunter' UAV Characteristics

Basically, the system was developed having in mind the real working conditions from the agricultural fields, that require rapid development, small take-off and landing spaces, long endurance - possibility to change rapidly the flight battery or to charge it from the car's battery, long flight radius, ruggedness, reliability and a friendly/easy to use control/programming interface, that not require a specialized pilot.

Depending on the GDS (ground sample distance-cm/pixel), a flight up to 30 minutes can lead to a map of an area of a 5-10ha land/crop. The GSD depends on the camera's resolution and flight altitude. Further analysis for map development depends on the number of pictures; their resolution and computer performances and it can take from a few minutes till a few hours.

CONCLUSIONS

The paper outlines the current state of the use of UAV systems worldwide, highlighting various aspects and advantages as a feasible alternative or as a complementary method for various agricultural and environmental applications.

Researchers, farmers and other categories of professionals are benefiting with relevant information collected via the various sensors mounted on UAVs (colour cameras / RGB, NIR cameras, IR cameras, weather sensors, gas detection sensors etc.) useful for developing research programs in order to support crop health, improve field management practices, reduce costs and increase yields.

UAV systems represent very useful tools for specialists in agriculture, providing them information to which they had not access through other sources, enabling them to make optimal decisions on crop management.

The UAV system multi-rotor type, equipped with various sensors that have been developed and tested in Romania represent a custom made solution for Precision Agriculture providing to all professionals interested the opportunity to collaborate in developing new projects in agricultural research and forestry.

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