THE USE OF DRONES IN MODERN AGRICULTURE

MIHALACHE D.B.[1*], VANGHELE N.A.[1], PETRE A.A.[1], MATACHE A.[1]

[*1] INMA Bucharest; Tel: 0212693259; E-mail: mihalache65@gmail.com

Keywords: drones, management, data, production

ABSTRACT

Drones are largely associated with military, industrial and other specialized operations, but with recent developments in sensors and information technology over the past two decades, the scope of drones has been expanded to other areas, such as agriculture.

This approach to agricultural management is based on the observation, measurement and measurement of real-time data on crops and animals. It removes the need for assumptions in modern agriculture and instead gives farmers the ability to maximize their yields while increasing crop production.

This paper presents a brief summary of drone implementation in agriculture.

INTRODUCTION:

The term “drone” first appeared in the early 16th century to indicate a male honeybee. The honeybee drone has a single purpose, to fertilize a queen bee during a mating flight, followed by the death of the drone. After World War Two this idea was applied to coin a word for pilotless aircraft used for target practice—a mission with a single purpose involving the destruction of the aircraft. [1]

Currently, the practical applications for drones are expanding from enthusiasts to industries and other areas like photography, package delivery, emergency response etc. Among various promising areas, Agriculture is regarded as one of the most important area where different varieties with feature packed facilities are required overcoming several challenges of farmers for better crop yield.[11]

Bellow, we have a number of various advantages and applications for drones in agriculture now used day by day.

Time saving - Farmers with a lot of hectares find it difficult to reach each corner of the field for inspection time to time. A drone does this task without any intreruption as farmers can do regular air monitoring of field to know the status of their crops at regular intervals of time.

Higher prodcution yield - The precision application of pesticides, water and use of fertilizers accurately monitored by drone will in turn increase the yield and overall quality.

Farm Analysis - Drones are reliable instruments flying in the sky and can be used by farmers to inspect the farm condition at the beginning of any crop year. Drones generate 3-D maps for soil analysis which is useful for farmers to plant the seeds. Soil and field analysis via drones also provides data useful for irrigation and nitrogen level management.

Crop Health imaging – By using drones equipped with infrared cameras, NDVI (normalized difference vegetation index) (Fig.1) and multispectral sensors, farmers can track crop health, transpiration rates, sunlight absorbtion rates etc.

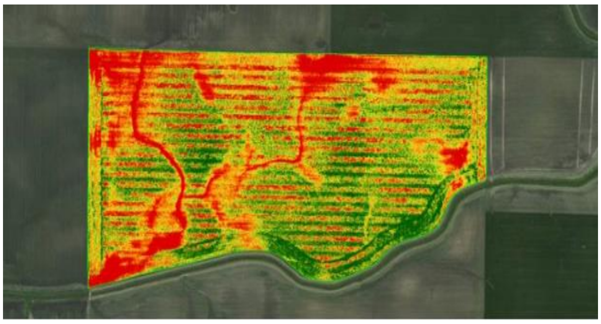

Fig 1 – NDVI Image

MATERIAL AND METHOD:

Electromagnetic energy interaction with plants and soil

During daytime, exposed surfaces on earth are constantly blasted with electromagnetic radiation originating from the sun and spanning a wide range of waveleghths. The relevant wavelengths are detectable by the silicon-based optical imaging sensors used in modern digital cameras, and although only part of this spectrum, from 400 to 700 nm.

Reflection, absorption and transmission

Light that interacts with soil or plant surfaces can be reflected, absorbed or transmitted. The absorption efficiencies of various wavelengths are determined by the quantum nature of light interactions with matter. Specific wavelengths cause specific energy-transitions in atoms and molecules that lead to conversion of light energy to other forms, such as heat. In the case of plants, the absorbed energy can also be utilized to drive photosynthesis .[4] If light does not encounter atomic or molecular structures that can absorb its energy, it will be reflected or transmitted.

A degree of light transmission is typical for most green vegetation, and transmitted light passing through the surface layer of plant tissue will interact with lower tissue layers. The secondary interactions include a degree of reflection back toward the surface layer, where it can interact with the surface layer again. This process results in a degree of added apparent reflectance from the surface layer, and therefore the total reflected light that reaches an airborne sensor .[15] Primary reflection of light from surfaces is, however, the major source of information reaching airborne sensors in most practical scenarios. The information derived from analysis of relative reflection efficiency at various wavelengths therefore relates mostly to the material composition of the uppermost exposed surfaces of soil and plants.

Types of cameras for drones

The amount of reflected light that is directed toward a sensor in the sky is influenced by the light scatter patterns from surfaces. The scatter pattern depends on the location, size, shape and texture of reflecting objects. Specular (mirror-like) reflection occurs to some extent from most natural surfaces, including plants, and the amount is related to plant structure and growth stage. The majority of reflected light from natural surfaces, however, scatter in a variably diffuse patterns depending on the specific surface characteristics .[12] This leads to changes in reflected light intensity reaching a sensor depending on the changing location of the sensor Therefore, as a drone moves through the air, the reflectance value from an object will change as the view angle changes. The resulting data patterns are typically referred to as bidirectional reflectance, and it is a commonly encountered artifact of remotely sensed data that often requires correction.[9] Bidirectional reflectance artifacts are particularly significant in drone-derived data due to the relatively wide-angle lenses used on drone-mounted sensors and the low flight altitudes typical of agricultural drone applications.

Drone mounted sensors in agriculture:

Visible light

Red, green, blue (RGB) sensors are the least expensive and most common passive sensor type used on drones. These sensors capture visible light (400–700 nm wavelengths) in overlapping red, green, and blue channels, similar to human vision.

Multispectral Camera

Multispectral cameras are one of the most commonly used sensors in addition to RGB cameras in the UAV sensors family, because of their benefits of obtaining spectral information in the red-edge and near-infrared band for vegetation applications in an extremely high resolution. Near-infrared cameras (e.g., Canon PowerShot SX260) can be used to derive vegetation indices (VIs) such as Normalized Difference Vegetation Index (NDVI) and others such as Green Normalized Difference Vegetation Index (GNDVI) and Enhanced Normalized Difference Vegetation Index (ENDVI).

LiDAR Camera

LiDAR is an active sensor type that can be defined as a portmanteau of light and radar, as it uses a laser to emit light and then measures the time for that light to reflect off an object and return to the sensor. This time delay measurement creates three-dimensional points indicating distance from the sensor, typically thousands of times per second. The resulting data can be used to describe a surface, usually in the form of a point cloud. If available, it canbe combined with other information, such as intensity and color of reflected visible light. LiDAR data excels at providing topography data without the image overlap requirement associated with regular aerial imagery, thereby increasing topographical mapping efficiency. It can also differentiate between plant canopy height and ground height, allowing plant canopy volumes to be calculated.[10]

RESULTS AND DISCUSSIONS:

Weed detection and mapping

Weed mapping is a commonly used application of remote sensing in agriculture[7] , and drones offer advantages in this application due to the high degree of flexibility in spatial resolution.[8].

Multispectral imagery is typically most appropriate for mapping weeds within the crop field. Successful mapping of weeds requires the agronomist to work closely with the image analyst to ensure understanding of the form and phenology of the weed and how they are different from the crop species. Some weeds are visually and spectrally similar to the crop species and are difficult or impossible to separate, while other weed species may be very different from the crop species, and weed identification and classification are therefore possible using aerial imagery. Following aerial data acquisition, the analyst must preprocess the imagery and classify crop cover, weed cover, and soil cover using the density slicing or image classification techniques described previously. Within-field zones where weed density is greater can be identified using vectorized weed and crop cover maps.

Water management

Limited availability of water is one of the most significant challenges facing agriculture today, and pressures on water resources are expected to increase into the future. Protecting crops from drought-related losses requires water management systems that respond to changing water needs in near real time, and therefore requires accurate data that reflect developing water deficits before those deficits lead to loss of production. Soil moisture sensors are typically deployed at few selected locations within the field to quantify soil moisture depletion in the soil profile. Irrigation system managers used information from soil moisture sensors including prior knowledge of crop type, soil characteristics, and environmental conditions such as temperature, precipitation and humidity to judge water needs. However, the limitations of these sources of information become apparent when the system becomes stressed because it is often not possible to see damaging stress before it becomes relatively severe and results in losses. Current soil moisture sensing systems often do not provide an opportunity to examine water stress at the desired spatial and temporal scale, which is particularly relevant due to the inherent variability of soil moisture depletion within the field. Modern variable rate water distribution systems allow irrigation managers to alter water distribution to sections of a field according to its specific needs. Such systems are available today, but sensing systems to rapidly collect crop growth, analytics to drive decisions, and models to use decision for irrigation scheduling, need to be matched with the spatial and temporal data requirements to make optimal use of these systems. Data need to be generated at the time of need, and at spatial scales that allow in-field adjustments to be optimized. Drones can play an important role in the evolution of irrigation systems by increasing the efficiency of data-generation.[2] Aerial sensing systems can provide robust spatial and temporal assessment of crop water stress (Fig. 2) under diverse environmental conditions, and with unmatched levels of data generation efficiency. The use/installation of newer variable rate irrigation technologies can be expected to rise as user confidence in spatial crop water assessment technologies is increasing and older systems are replaced or upgraded. This evolution of irrigation systems, from blunt instruments that often over- or under-supply water to different parts of fields, to systems that can optimize water supply in all areas of a field, greatly enhances the sustainability of available water resources while optimizing crop yields

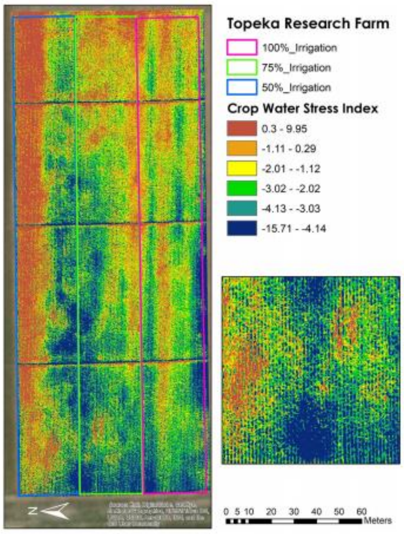

Fig 2- A crop water stress map generated from a thermal infrared imagery of corn crop using environmental parameters. The three irrigation regimens are shown in boundaries marked with pink, green and blue solid lines

Temperature screening for livestock

Elevated body temperature is often associated with infectious diseases in livestock, and measurement of body temperature is therefore an important tool in the screening of livestock for the possible presence of infections. [3] Skin surface temperature can also be used to detect heat stress in livestock, and changes in local blood flow patterns associated with inflammation can be used to locate inflammatory lesions.[6] Most traditional methods of temperature measurement require restraint and close physical contact with animals. This has several serious disadvantages, including poor efficiency in terms of speed and labor, increased stress in livestock that results in decreased performance and animal well-being, and an increased potential for the spread of infections through close contact between animals and close contact between workers and successive groups of animals. High resolution thermography, based on uncooled, light weight thermal cameras mounted on drones, offers an alternative screening method that is highly efficient, and does not require livestock to be restrained or physically handled. Thermography sensors detect the infrared radiation emitted by objects at biologically relevant temperatures, in the wavelength range of approximately 8–12μm.[5] It should be noted, however, that body temperature screening is not by itself enough to identify and diagnose infections but is best used as an adjunct to ground-level inspections that can make those inspections more efficient shown in Figure 3. The potential benefits are particularly high in areas of livestock concentration, such as feedlot systems, where groups of animals can be screened based on pen locations, followed by detailed ground-based inspections of pens where animals with elevated body temperature were identified.

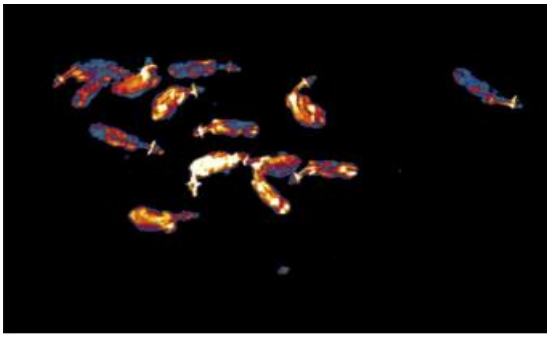

Fig. – 3 A colorized thermal image demonstrating observable differences in skin surface temperatures associated with fever reactions in cattle (yellow to white coloration), compared to normal animals (red to blue coloration).

CONCLUSIONS:

In conclusion, autonomous monitoring and sampling are expected to become increasingly reliable and sophisticated and could play important roles in the future development of precision agriculture and food security. Lack of universal public acceptance and unsuitable regulatory frameworks are some of the challenges that limit the pace of application development and expansion of drone use. If these challenges can be surmounted, future drones could be hosted at strategic locations, and will execute a variety of local crop monitoring tasks that are controlled through autonomous features under the direction of centralized operations centers where large amounts of data can be utilized to extract reliable, near-real time information for use in management decision-making.

ACKNOWLEDGEMENT:

This work was supported by a grant of the Ministry of Education and Research on the Programme 1 – Development of the national research-development system, subprogramme 1.2 – Institutional performance – Projects for financing excellence in RDI, contract no. 16 PFE

BIBLIOGRAPHY:

1. Deon van der Merwea, David R. Burchfieldb , Trevor D. Wittb , Kevin P. Pricec , Ajay Shardad (2020). Drones in agriculture
2. Gago, J., Douthe, C.,Coopman, R.E., Gallego, P.P., Ribas- Carbo, M., Flexas, J.,Escalona. (2015). UAV's challenge to assess water stresss for sustainable agriculture
3. Gloster, J., Ebert, K., Gubbins, S., Bashiruddin, J.,Paton, D.J. (2011). Normal varations in thermal radiated temperaturein cattle: implications for foot-and-mouth disease detection
4. Kiang, N.Y., Siefert, J., Govindjee, Blankenship, R.E., (2007). Spectral signatures of photosynthesis.
5. Mccafferty, D.J.(2007). The value of infrared themography for research on mammals: previus application and future directions. Mammal Rev. 37, 207-223
6. McManus, C., Tanure, C.B., Peripolli, V., Seisax, L., Fischer, V., Gabbi, A.M., Menegassi, S.R.O (2016). Infrared thermography in animal production: and overview

7. Thorp, K.R., Tian, L.F., 2004. A review on remote sensing of weeds in agriculture.
8. Rasmussen, J., Nielsen, J., Garcia-Ruiz, F., Christensen, S., Streibing, J.C., (2013). Potential uses of small unmanned aircraft syste,s (UAS) in weed research
9. Roujean, J.-L., Leroy, M., Deschamps, P. – Y. (1992). A biodirectional reflectance model of the Earth's surface for the correction of remote sensing data.
10. Rosell, J.R., Llorens, J., Sanz, R., Arno, J.,Ribes-Dasi, M.,Masip, J., (2009). Obtaining three-dimensional structure of tree orchards from remote 2D terrestrial LiDAR scaning
11. Poonia, Ramesh (2017) Viability Analysis of TwoRayGround and Nakagami Model for Vehicular Ad-Hoc Networks, International Journal of Applied Evolutionary Computation (IJAEC) 8.2; 2017; 44-57
12. Vanderbilt, V.C., Grant, L. (1985). Plant canopy specular reflectance model
13. Vikram Puri, Anand Nayyar & Linesh Raja Vikram Puri, Anand Nayyar & Linesh Raja (2017). Agriculture drones: A modern breakthrough in precision agriculture, Journal of Statistics and Management Systems, 20:4, 507-518, DOI: 10.1080/09720510.2017.1395171 2017
14. Vergouw B, H Nagel, G Bondt, B Custers (2016) - The future of drone use
15. Yamada, N.,Fujimura, S. (1991). Nondestructive measurement of chlorophyll pigment content in plant leaves from three-color reflectance and transmittance. Appl. Optics 30, 3964-3973
16. https://www.helimetrex.com.au/wp-content/uploads/2018/10/NDVI-Survey-Map.jpg