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A Review on the Application of Drone in Agriculture

Alisha Snigdha[1]* and Dr. Tushar Ranjan Mohanty[2]

Department of Agriculture Meteorology, College of Agriculture, OUAT, Bhubaneswar
Department of Agriculture Meteorology, AICRP on Agrometeorology, OUAT, Bhubaneswar

Corresponding Author
Alisha Snigdha
Email: alishapathya@gmail.com

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ABSTRACT

The need for food is rising in tandem with the population's rapid growth. Farmers were unable to meet these standards using their existing ways. As a result, drone technology and other automated techniques were presented. In addition to meeting the world's food needs, these new techniques gave billions of people jobs. Drone technologies reduce the need for excessive amounts of water, pesticides, and herbicides, preserve soil fertility, aid in the effective use of labor, increase productivity, and enhance quality. This paper's goal is to examine how drones are used in agricultural applications. According to the literature, drones can be used for a wide range of agricultural purposes. We employed a thorough evaluation of previous studies conducted worldwide as part of our methodology. The present state of drone technology for agricultural applications, such as crop health monitoring and farm activities including weed control, evapotranspiration estimation, spraying, etc., is compiled in this paper. In order to improve agricultural production, the research article's conclusion is that more farmers invest in drone technology.

INTRODUCTION

Even though India relies heavily on agriculture, it still lags behind in implementing the newest technologies to produce high-quality farms (Natu & Kulkarni, 2016; Zhang & Kovacs, 2012). Developed nations have already begun using

UAVs for remote sensing (Everaerts, 2008, Colomina & Molina, 2014), photogrammetry, and precision agriculture. It is incredibly quick and might lighten a farmer's workload. UAVs typically have cameras, sensors, and sprayers for monitoring crops and applying pesticides. Numerous UAV variants have already been used for both military and civilian purposes (Van Blyenburgh, 1999). Applying UAVs to agricultural tasks such as crop monitoring (Bendig *et al*., 2012), crop height estimation, pesticide spraying (Huang *et al*., 2009), and soil and field analysis is a technical analysis of precision agriculture.

But their hardware implementations are entirely dependent on important factors including payload, configuration, weight, range of flight, and cost. For a long time, drones were considered pricey toys. The agriculture industry is one that has received little drone attention, maybe to its detriment. With specialized software that enables flight planning, GPS deployment, and the input of several parameters including speed, altitude, ROI (Region of Interest), geo-fence, and fail-safe modes, drones can fly autonomously. High spatial resolution, quick turnaround times, cheap operating costs, and ease of use are some of the main reasons why drones are chosen over full-size aircraft. These characteristics are necessary for precision agriculture, which monitors vast areas and conducts analysis quickly. The shrinking of small cameras and other sensors, such as sonar and infrared, has made it feasible to use airborne vehicles. In the 1980s (Nonami, 2007) and the Japanese were the first to effectively use UAS technology for crop dusting and agricultural chemical spraying, respectively. 1,220 Yamaha unmanned helicopters had been sold and were operational in Japan as of 2001. Approximately 40% of Japan's rice paddies are sprayed annually by more than 2,000 Yamaha RMAX unmanned hellos, which cover roughly 2.5 million acres. In terms of UAV agricultural uses, the United States lags behind Japan, and proponents must negotiate a complex web of privacy and legal concerns before allowing their lawful introduction into society. Even if the usage of UAVs in agriculture has been growing gradually, there are still a lot of technical obstacles that need to be solved. Stress detection and quantification is undoubtedly the application that has drawn the most interest among them, probably because of the possible advantages. influence on agricultural activity that can result from early stress diagnosis. As a result, a great deal of data has been produced and numerous approaches have been put out, making it challenging to monitor the state of the art in this area and the primary obstacles that still need to be addressed. This article's goal is to give a thorough explanation of how drones, or unmanned aerial vehicles, are used in agriculture to monitor and evaluate plant stressors like drought, diseases, malnutrition, pests, and weeds, among others.

Precision agricultural activities include crop monitoring for pests, nutrients, disease, water stress, and general plant health. Traditionally, this has been done by ground or aerial study, but the availability and operational costs of these techniques limit their use. Light aircraft imagery is typically more up-to-date, less expensive, and has higher resolution, but it is still somewhat pricey per acre. In order to continuously cover the crop fields, small UAVs or UAS can fly regularly with repeatability of route and altitude and collect temporal/spatial data with a resolution of centimeters. UAVs can easily acquire the photos, and cloud cover has less of an impact. As previously mentioned, UAS have been applied in a variety of agricultural fields, despite the fact that they still face numerous obstacles and constraints. The main UAS technology and applications for agriculture are outlined in this study, along with the difficulties of applying UAS in an agricultural setting.

Crop Health Monitoring

In order to take prompt, need-based action, drones can be used to monitor agricultural conditions throughout the growing season. Several multispectral indices can be calculated based on the reflection pattern at various wavelengths by employing various types of sensors related to visible, near-infrared, and thermal infrared radiation. These indices can be used to evaluate agricultural conditions such as diseases, insect-pest attacks, nutrient stress, and water stress. The sensors on the drones are able to detect the prevalence of illnesses or deficiencies before any outward signs show up. They therefore act as a tool for early disease detection. Drones can be utilized as an early warning system in this manner, allowing for prompt action to be made by implementing corrective measures according to the level of stress. A variety of indices can be used by UAVs (drones) to observe the crop (Simelli & Tsangaris, 2015). The UAVs can fly over hectares of land in a single flight. The quadcopter's underside is equipped with thermal and multispectral cameras (Colomina & Molina, 2014) to record the reflectance of the vegetative canopy for this observation. Each second, the camera records a single image, saves it in memory, and transmits it via telemetry to the ground station. The Normalized Difference Vegetation Index (NDVI), a geographic indication that is represented in an equation, was used to analyze the data obtained from the multispectral camera via telemetry

The discrepancy in normalization: The health of green vegetation is indicated by a straightforward metric called the vegetation index. According to the basic idea, red and blue light are absorbed by chlorophyll while near infrared light (NIR, or about 750 nm) is significantly reflected. Because chlorophyll reflects so well, plants appear green to us, but their NIR reflection is even higher. This is a crucial factor that aids in providing accurate data for analysis. Near 0 (ZERO) denotes no vegetation on the crop, and near +1 (0.8 to 0.9) denotes the highest density of green leaves on the crop, according to the computations, which yield values between -1 and +1 (Sato A 2003). Farmers can quickly determine the health status of their crops and keep an eye on them based on these results. These findings make it simple for farmers to determine which fields are suitable for pesticide application. In order to take prompt, need-based action, drones can be used to monitor agricultural conditions throughout the growing season. Yield loss can be avoided by taking prompt and suitable action. Thanks to this technology, farmers won't need to visually inspect their crops. They are able to keep an eye on the horticulture crops and other crops that are grown in far-flung places like mountainous regions. Additionally, they can effectively monitor trees and tall crops that are difficult for farmers to manually scout.

NDVI = (RNIR – RRED)/ (RNIR + RRED)

RNIR = Reflectance of the near infrared band.

RRED = Reflectance of the red band.

Water Stress Monitoring

The consequences of drought are influenced by a number of factors, making it difficult to characterize water stress on crops. Variables obtained from thermal imaging frequently use minute changes in temperature to identify stressors and other occurrences. Consequently, thresholds and regression equations that are developed under specific conditions typically do not hold under even somewhat different settings. Because stomatal conductance and transpiration rates vary naturally among genotypes of a particular crop, for instance, they may exhibit noticeably different canopy temperatures under the same circumstances.

Studies identified water stresses using a variety of sensors and models, including:

Utilizing hyperspectral or multispectral images, the vegetation indices (NDVI, GNDVI) utilized are the outcome of spectral transformations meant to draw attention to specific vegetation characteristics. A reflectance measurement sensitive to variations in the carotenoid pigments found in leaves is the photochemical reflectance index (PRI), which is employed in conjunction with multispectral or hyperspectral images. Although some studies use the canopy temperature directly, others use thermal infrared imagery and the difference between the canopy and air temperatures (Tc - Ta). Thermal infrared imagery and the crop water stress index (CWSI), which is based on the difference between canopy and air temperatures (Tc - Ta) and is normalized by the vapour pressure deficit (VPD). In certain studies, a related variable known as Non-Water Stress Baseline (NWSB) was also employed. This is justified by the fact that water stress causes plants to exhibit reduced stomatal conductance and heat dissipation, which results in a discernible rise in canopy temperature. When calculating hybrid variables like the Water Deficit Index (WDI), Red-Green-Blue (RGB) images are typically used in conjunction with thermal or multispectral images (Hoffmann *et al*., 2016). Additionally, the issue of water stress has occasionally been addressed through the use of narrow-band multispectral images to calculate chlorophyll fluorescence.

Nutrient Status and Deficiency Monitoring

Because stomatal conductance and transpiration rates vary naturally among genotypes of a similar crop, for instance, they may exhibit markedly varying canopy temperatures under the same circumstances.

Researchers discovered water stressors using a number of sensors and models, including: Utilizing hyperspectral or multispectral pictures, the vegetation indices (NDVI, GNDVI, etc.) (Zarco-Tejada, Gonzalez-Dugo, & Berni, 2013) are the product of spectral alterations aimed to call attention to certain vegetation characteristics. A reflectance measurement sensitive to fluctuations in the carotenoid pigments found in leaves is the photochemical reflectance index (PRI) (Berni *et al*., 2013) in conjunction with multispectral or hyperspectral images. Although some research employs the canopy temperature directly, others use thermal infrared images and the difference between the canopy and air temperatures (Tc – Ta). Thermal infrared imagery and the crop water stress index (CWSI), which is based on the difference between canopy and air temperatures (Tc - Ta) and is normalized by the vapour pressure deficit (VPD) (Park *et al*., 2017). In select investigations, a related variable known as Non-Water Stress Baseline (NWSB) was also applied (Gonzalez-Dugo *at al*., 2014).

This is justified by the fact that water stress leads plants to exhibit lower stomatal conductance and heat dissipation, which results in a detectable rise in canopy temperature (Primicerio *et al*., 2012). When computing hybrid variables like the Water Deficit Index (WDI), Red-Green-Blue (RGB) photos are frequently utilized in conjunction with thermal or multispectral images. Additionally, the issue of water stress has occasionally been addressed by the use of narrow-band multispectral pictures to determine chlorophyll fluorescence.

Under the same conditions, for example, different genotypes of a given crop may show notably varied canopy temperatures due to natural differences in stomatal conductance and transpiration rates (Maurya, 2015). Researchers used a range of sensors and models to identify water stressors, such as: The NDVI, GNDVI, and other vegetation indices (Berni *et al*., 2013; Zarco-Tejada, Gonzalez-Dugo, & Berni, 2013) are the result of spectral manipulations intended to highlight certain vegetation features using hyperspectral or multispectral pictures. Relative to multispectral or hyperspectral images, the photochemical reflectance index (PRI) is used in references as a reflectance measurement sensitive to changes in the carotenoid pigments present in leaves. While some research employs the canopy temperature directly, others make use of thermal infrared images and the canopy-to-air temperature differential (Tc-Ta) as reported in some studies. References make use of thermal infrared images and the crop water stress index (CWSI), which is adjusted by the vapour pressure deficit (VPD) and is based on the difference between canopy and air temperatures (Tc - Ta). Some studies also used a comparable metric called Non-Water Stress Baseline (NWSB). Water stress causes plants to show decreased stomatal conductance and heat dissipation, which leads to a noticeable increase in canopy temperature. This justifies this. The Water Deficit Index (WDI) and other hybrid variables are often calculated using RGB photos in combination with thermal or multispectral images (Dutta & Goswami, 2020). Furthermore, the problem of water stress has been treated on occasion by calculating chlorophyll fluorescence using narrow-band multispectral pictures.

Drone for Evapotranspiration Estimation

The process by which water is moved from the land to the atmosphere by transpiration from live plants and evaporation from the soil is known as evapotranspiration, or ET. The hydrology, agricultural, and water management professions employ estimates of potential ET.

Climate change, population growth, and water shortage have made evapotranspiration estimation one of the most crucial agricultural research topics in recent years. Unmanned aerial vehicles of various types are employed for ET estimate in various research projects. Generally, there are three types of UAV platforms: quadcopters, fixed-wings, and aircraft. Although aircraft are often costly, they can carry large sensors and fly for longer. Quadcopters and fixed-wing aircraft are less expensive than airplanes. Typically, fixed-wing aircraft can fly for two hours, making them appropriate for big fields.

A quadcopter's 30-minute flying time makes it ideal for short-distance missions in a limited area. As a platform for remote sensing, UAVs also raise new research issues like flight path planning and drone image processing. Using two source energy balance models, a fixed-wing UAV will gather thermal data to determine ET (Maurya, 2015). Very-high-resolution footage from a UAV platform (S1000, DJI, Shenzhen, China) was used to quantify evapotranspiration in a peach orchard (Dash, *et al*. 2018). Additionally installed on the drone are a multispectral camera RedEdge (MicaSense, Seattle, WA, USA) and a TIR camera (A65, FLIR Systems Inc.). Using an airborne digital system for evapotranspiration estimation created by Utah State University, multispectral and thermal images were gathered (Simelli & Tsangaris, 2015). These cameras have blue (0.465 µm – 0.475 µm), green (0.545 µm – 0.555 µm), red (0.645 µm – 0.655 µm), and near-infrared (NIR) (0.780 µm – 0.820 µm) spectral bands. Additionally installed on the aircraft is a Thermal CAM SC640 (FLIR Systems Inc.), which captures thermal infrared (TIR) images with a wavelength range of 7.5 µm to 13 µm. Lightweight sensors and UAV platforms can offer superior quality, wider geographical and temporal resolution as compared to traditional satellite-based remote sensing techniques.

CONCLUSION

Indian agriculture could undergo a significant transformation because to drones. Drone manufacturing is anticipated to become more cost-effective in the future as technology advances. The labor-intensive and tedious nature of farming deters today's youth from pursuing it. Drones may captivate young people and inspire them to pursue careers in agriculture. Compared to satellite imagery, drones offer high-quality, real-time aerial imagery over agricultural regions. Additionally, drones can also be used to locate weeds and illnesses, assess soil characteristics, identify vegetation variations, and create precise elevation models. With drones, farmers will be able to learn more about their farms. Consequently, farmers will receive support to increase food production while utilizing fewer chemicals. The majority of farmers who have used drones have benefited in some way. They can manage their land more effectively, eradicate pests before they ruin entire crops, increase irrigation for plants that are vulnerable to heat stress, track fires before they become out of hand, and modify the soil quality to enhance development in troublesome regions. Therefore, by assisting farmers in better and more sustainable field and resource management, drones may eventually become a standard component of agriculture.

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