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Application of Unmanned Aerial Vehicles (UAVs) in Agriculture

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Abstract

Agriculture is the key component of global economy, which is the primary source of food, revenue, and employment. More than 70% of rural people particularly in developing countries like India depend on agriculture. Even India depends heavily on agriculture; it still falls far short of adopting the newest technologies to produce high-quality farms. Diseases Insects/pests and other factors causes agriculture crops to suffer significant losses. To improve crop quality and better production, pesticides/insecticides and fertilizers are sprayed. In order to prevent health issues for people when manually applying pesticides, unmanned aerial vehicle (UAV) aircraft are utilized. Developed countries have already started utilizing UAVs technology which is equipped with sprayers for applying pesticides and cameras and sensors for monitoring crops. In situations where labour and equipment are difficult to handle, UAVs can be used effectively. This study provides a brief overview of the use of UAVs in crop monitoring and spraying.

Keywords: Crop Monitoring; NDVI; Sensors; Spraying; Unmanned Aerial Vehicle

Abbreviations

UAVs: Unmanned Aerial Vehicles; RPAS: Remotely Piloted Aircraft Systems; GRVI: (Green/Red Vegetation Index; GI: Greenness Index; ExG: Excessive Greenness; PRI: Photochemical Reflectance Index; CWSI: Crop Water Stress Index.

Introduction

Unmanned Aerial Vehicles (UAVs) are flying machines that use GPS coordinates and an autopilot to fly a predetermined course. Drones, usually referred to as unmanned aerial vehicles, are becoming more popular in agriculture [1]. Drone technology is a phenomenal innovation that has the ability to completely change how agriculture does its routine activities. Drone technology is being used by agricultural industries around the world to improve traditional farming practices. Drones can be equipped with payloads to carry out certain tasks, such cameras, spraying systems, etc. While there are various acronyms that can be used interchangeably, such as UAV/UAVs (Unmanned Aerial Vehicle/Systems) and UAS (Unmanned Aircraft Systems), the most formal and globally recognised term for these systems is Remotely Piloted Aircraft Systems (RPAS). Agriculture drones are drones that are utilized for agricultural purposes [2]. The UAV's sensors enable highly accurate small-scale treatment of agricultural crop and livestock. Utilizing GPS guidance combined with

UAV technology can increase production while lowering agrochemical inputs, fuel and crop management time. By its application, more sustainable agriculture is expected to meet current and future demands for food and other agricultural product without sacrificing sustainability [3].

Technology Implicated in UAVs

UAVs have become a standard tool in precision agriculture. UAVs are frequently the most common choice for accurate and timely in situ remote sensing or survey. Despite their adaptability, these systems can serve a variety of functions based on the sensors they contain. In order to improve the management of timely field activities, ongoing research is examining the best ways to combine data from ground sensors, UAV sensors, and other data sources [4]. Smart agriculture and big data management are two areas of particular significance. UAV systems provide advantages like it has the ability to gather readily accessible data in real time (without the need for post-processing). Besides they also enable operators to gather data even in bad weather conditions such extremely cloudy or foggy days, when satellite detection systems fail or produce significantly different datasets. UAVs can be used even to survey locations that are hazardous or hard to reach. The most significant sensors that are available as payload can be broadly divided into three types based on the number and spectrum length of data they can record. They are

- VIS (Visible sensors) or RGB (Red, Green, Blue) sensor
- Multispectral sensors
- Hyperspectral sensors

RGB (Red, Green, Blue) sensor**/VIS**(Visible sensors): With acceptable or high accuracy, these sensors are used to determine vegetation indices like the Green/Red Vegetation Index (GRVI), Greenness Index (GI), and Excessive Greenness (ExG). RGB sensors have also been used increasingly in machine learning techniques for phenology, diseases, object recognition, and similar fields.

Multispectral sensors: The multispectral sensors are used for a wider range of calculations of vegetation indices as they can rely on a higher number of radiometric bands. With multispectral sensors, the range of vegetation indices that can be monitored is considerably extended compared to those that can be calculated with only three RGB bands.

Because multispectral sensors may rely on a larger number of radiometric bands, they are used for a wider range of vegetation index computations [5]. When using multispectral sensors, the range of plant indices that may be tracked is far larger than when using simply three RGB bands to calculate them.

Hyper Spectral Sensors: The hyperspectral sensors can record hundreds to thousands of narrow radiometric bands, usually in visible and infrared ranges. Each band or combination of bands, being very narrow, can detect a specific field characteristic. They are heavier and bigger than other sensors, often making their use on UAV systems difficult and excessively in terms of payload.

Application of Drones in Agriculture

Crop Health Monitoring: Throughout the crop season, drones can be used to monitor crop conditions, enabling timely and necessary action to be made. According to the reflection pattern at various wavelengths, various multispectral indices can be calculated by utilizing various types of sensors related to visible, near-infrared, and thermal infrared radiation. These indices can be used to evaluate various crops situations, such as nutrient stress, insect-pest attack, diseases, and water stress. Even before symptoms become visible, the sensors installed on the drones can detect the incidence of diseases or deficiencies. As a result, drone can be used as a tool for early disease identification. In this way, drones can be used for early warning system so that timely action can be taken by applying the remedial measures based on the degree of the stress.

Spraying: For Indian agriculture to reach high productivity levels, production and protection materials were required. Fertilizer and chemicals for agriculture are often required in order to kill insects and promote crop development. Drones can be used to spray chemicals like fertilizers, pesticides, etc. based on the spatial variability of the crops and field. Depending on the crop conditions or the intensity of the insect-pest attack, the quantity of chemicals to be sprayed can be adjusted. This is most important operation in crop life cycle. For crops to continue producing large yields, frequent fertilization and spraying are necessary. Traditionally this was done manually, with vehicles or even with airplane (in some parts of the world). These methods are not only inefficient and burdensome but they can be very costly as well. Drones can be equipped with large reservoirs which can be filled with fertilizers, herbicides or pesticides. Crop spraying is significantly safer and more economical when done are used. Even more advanced drones can be programmed to operate entirely on their own, following predetermined routes and schedules.

Nutrient Deficiency Monitoring: To produce high yield and for better development of crop, right amount of nutrient are required. So suitable amounts of nitrogen are essential for strong foliage and vegetation growth, appropriate amounts of phosphorous are needed for sturdy root and stem growth; and appropriate amounts of potassium are needed to improve disease resistance and provide higher-quality crop production. Any deficiency in these nutrients in the soil can cause stress to the plant, making it difficult for plant to grow. Using NDVI (Normalized Difference Vegetation Index) mosaics, it is possible to determine the precise crop areas

that are under stress or have trouble in growing and can take immediate action. Before the problem become visible to the naked eye, these management zones can be identified using the NIR/multispectral imaging that the UAVs offer. Thus it is possible to target these management zones before it impact on crop development and yield.

Irrigation Management and Monitoring: Thermal camera-equipped drones can be used to identify irrigation problems or locations that receive an unusually high or low amount of precipitation. With this knowledge, crop layouts can be improved to take advantage of drainage, follow the patterns of natural land runoff, and prevent water pooling, which can harm susceptible crops. Problems with water and irrigation can destroy crop production in addition to being expensive. These problems can be identified through drone surveys before they become problematic.

Water Stress Monitoring: Due to the adverse effects of drought on crop productivity, characterizing water stress in crops is a challenging issue. In order to identify stresses and other phenomena, variables driven from thermal pictures frequently depend on extremely slight temperature fluctuations. To identify water stress, several kinds of sensors and models, including, hyper spectral or multispectral photographs and vegetation indices (NDVI, GNDVI, etc.) is the outcome of spectral transformations intended to emphasize specific characteristics of the vegetation. Photochemical reflectance index (PRI), which is used in multispectral or hyper spectral images, is a reflectance measurement sensitive to variations in carotenoid pigments present in leaves. The crop water stress index (CWSI), which is based on the difference between canopy and air temperatures and is normalized by the vapour pressure deficit, is calculated using thermal infrared images.

Planting Crop/ Sowing Seed: Drones are utilized in agriculture not just for providing information on weather report and other activities, but also to physically plant seeds in soil. Some drone manufacturing companies have been experimenting with this activity recently in order to provide quick, easy, and efficient smart agriculture methods. In an attempt to minimize human interaction, Drone Seed is a company that recently experimented with spraying seeds directly into the soil. They even sprayed water on the seeds which are planted.

Crop Loss Assessment during Natural Calamities: Drones are highly beneficial for monitoring, mapping, and damage assessment during disasters. In terms of cost and efficiency, drones seemed to offer considerable benefits over traditional techniques for disaster management. Compared to GPS surveys and satellite imagery, drones are more effective at producing high-quality images. After collecting the data, specialized software are used to process the images. This might include stitching together multiple images to create a detailed map or using algorithms to analyse crop health based on spectral data which help to assess the extent of the damage. This might involve identifying areas where crops are severely affected or estimating the percentage of loss. Drones were particularly useful for evaluating erosion and flooding because they required little time on-site and could offer continuous, detailed 2D and 3D data [6]. Furthermore, with the creation of a drone aerial photo sharing web system, drones can share information more effectively during the early phases of a disaster.

Benefits or Using Drones over other Methods: Quick data collection for precise agricultural analysis: 3D models and maps made with drone photometry are highly precise. The photos taken by the drone can be used to create a topographical map of the fields using mapping software like Pix4D Fields. This will assist farmers in making the required modifications for a healthy and productive land.

Time and money savings: When it comes to mapping, surveillance, and crop spraying, drones are faster and less expensive than manned aircraft. Drones operate through intelligent flight modes; they are semi-automated and time-efficient, allowing farmers to save money on labour and equipment by spending less time in the field.

Higher agricultural yield: Farmers may quickly detect unproductive areas of their field and adopt the necessary management techniques by using remote sensing technology. In the long run, this will increase yield, save costs, and enhance crop quality overall.

A safer method of crop spraying: Manual chemical spraying presents health risks. It is far safer and more effective to treat diseased plants with drones than it is to use land-based machinery and manual labour.

Conclusion

Drone technology can help farms and other agricultural businesses by improving crop yields, saving time, and make better land management decisions that will contribute to long-term profitability. Today's farmers deal with a wide range of complex problems such as water availability, climate change, wind, weeds, insects, and varying growing seasons that have an impact on the profitability of their agricultural enterprise [7-10]. Because of this, farmers are turning to advanced drone technology to solve these issues and provide immediate solutions. With the use of agricultural drones, farmers may access a variety of data that will help them optimize crop yields, improve management, and boost overall profitability. Then, using this data, more precise map of any problems that may exist can be obtained and based on that highly reliable information, solution can be developed. Drone technology is an emerging field in agriculture that will help farmers to meet the growing and changing demands of the future.

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