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Editorial

Application of Unmanned Aerial Vehicles in Precision Agriculture

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1. Introduction

Agriculture has long been an important part of human activities. As such, increasing agricultural production efficiency has posed difficulties for researchers in related industries. Revolutions in agricultural production technology are often accompanied by industrial revolution. As industry moves from its first to its fourth era, agriculture is also entering its fourth era; that is, traditional labor-intensive agriculture is being replaced by industrial agriculture [1], in which precision agriculture is important.

Scholars began to explore the precision agriculture operation mode starting from Agriculture 3.0 and basically formed a systematic understanding of it in Agriculture 4.0. Industrial and automated production methods reduce the need for human resources and increase efficiency but also create a shortcoming in terms of lower production quality. Compared with manual operation in traditional agriculture, the large-scale automated machinery widely used in industrial agriculture reduces operational accuracy and is more suitable for large areas and simple terrain. Therefore, the purpose of precision agriculture is to increase the operating accuracy of automated machinery.

In the aerial field of precision agriculture, UAV operation stands out among the automation machinery due to its high flexibility, ease of control, high adaptability to complex terrain, and high efficiency. Moreover, UAVs provide substantial advantages in many agricultural operations, such as air spraying, air sowing, remote sensing detection, and information collection. Therefore, research on drones is particularly important for the development of precision agriculture.

In this regard, the purpose of this Special Issue entitled "Application of UAVs in Precision Agriculture" is to raise the awareness of various UAV applications in precision agriculture and the current research progress. We paid special attention to the impact of pesticide and fertilizer distribution on crops and the importance of agricultural information collection. Therefore, this Special Issue focuses on the scientific contributions of UAVs in two aspects: air spraying and agricultural information monitoring.

2. Special Issue Overview

2.1. Air Spraying

In agricultural operations, the use of pesticide and fertilizers affects the quality of crop growth. The precise control of pesticide and fertilizer use, action area, and action site can increase the growth quality and yield of crops. Regarding pesticide spraying, two factors generally affect the distribution of pesticide on crops: the deposited amount and the penetration of the pesticide. The deposited amount of the pesticide refers to the average distribution amount of the pesticide per unit area. The penetration refers to the capacity of the pesticide to effectively permeate the crop canopy, enabling it to reach various areas within the crop. When these two values are low, that is, the fog droplets drift in the air, the pesticide efficacy decreases. In UAVs spraying operations, the main parameters affecting the two factors of pesticide distribution are the UAVs and the liquid nozzle carried by the UAVs.

From a macroscopic point of view, the UAV parameters include the flight route, altitude, speed, and UAV formation structure. From the perspective of operation efficiency, multiple-machine formation operation is superior and will be the operation mode used on future farms. Multiple-machine collaborative operation not only increases the operation efficiency but also produces better operation results. Chen et al. evaluated the operational effect of UAV formations. They designed and compared the effects of different flight routes, aerial team structures, and spraying modes of each aircraft in the UAV formation on the spraying operations [2]. They focused on the uniformity of the distribution of the pesticide solution in the overlapped area of the spraying and found that in the flight formation, the use of different spraying modes in the overlapped area of the outer fuselage and the overlapped area of the UAV route center achieved better application effects. However, modifying the route and spraying pattern does not solve the problem of drifting by a single drone. The authors propose that this requires further research and discussion of the internal composition parameters of the UAVs.

The internal composition parameters of UAVs, that is, from the microscopic point of view, include the rotor speed, rotor distribution, and nozzle distribution. The downwash wind field generated by the UAV rotor is an important factor that affects the spraying of fog droplets. The wind field increases the penetration of fog droplets, and the range of the wind field affects the deposited amount of the fog droplets. However, the interaction mechanism of wind fields, droplets, and crops is still unclear and has become a bottleneck restricting the increase in the deposition quality. Yang et al. proposed a method to study the distribution law of the downwash field of multirotor UAVs [3]. This method involves computer simulation calculations to establish a three-dimensional numerical calculation model for the downwash field of a six-rotor UAV under different pesticide loads and an analysis of the results. The results provide valuable guidance for the operational parameters of the UAVs, such as the flight height and nozzle installation position. Liu et al. focused on another direction—the product of the downwash air field under a UAV at the crop crown level: wind vortex [4]. In this study, the frame difference method was used to identify the wind vortex during flight. Through this more intuitive process, the UAVs operation parameters are linked to the wind vortex parameters, and the corresponding relationship is established to control the UAVs to achieve a better pesticide spraying effect. In terms of UAV control, Su et al. applied another approach [5]. They combined the agricultural characteristics of rice fertilization with single neuron adaptive proportional–integral–derivative (PID) control technology, which was improved via weighted coefficient learning, to study and design a real-time variable fertilization control system suitable for rice field operations in northern China. The experimental results show that the control method increases the uniformity and accuracy of fertilization.

As mentioned above, the study of the parameters of UAVs is not the only method of improving the operation effect of UAVs. Wang et al. evaluated the influence of different nozzles on fog droplet migration during operation [6]. According to the wind tunnel test results, the risk of drift of the fog droplets is higher with the centrifugal nozzle than with the hydraulic nozzle. The experimental results also show that the spray additives strongly affect reductions in the drift of the fog droplets. Liu et al. evaluated the spray drift reduction effect of four different spray auxiliaries during the liquid atomization of hydraulic nozzles [7]. Three commonly used commercial nozzles (XR, AIXR, and TXVK) were examined in terms of spray effects with different adjuvants (sodium dodecyl sulfate, aerosol OT, and 1% silicone). The drift was significantly reduced by changing the nozzle type and adding spray adjuvants to the spray solution. In the previous two studies, the researchers examined the existing products on the market, whereas Yang et al. studied and optimized the design and atomization performance of a pneumatic double atomization centrifugal atomizer [8]. In this study, the spray parameters and structural parameters were comprehensively considered, and the droplet volume median diameter (VMD) and spectral width (SRW) were used as evaluation indices to optimize the structure and atomization performance of the atomizer under different speeds and flow rates. Taking the effective strip width (ESW) of the optimized atomizer as the evaluation index, the effects of the speed, flow rate, and spray height on the performance of the atomizer were studied. This study provides a model reference for efficient UAV spraying.

2.2. Agricultural Information Monitoring

Whether during crop growth or during agricultural machinery operation, agricultural information is constantly being generated. This information includes not only the crop growth status, crop disease, and other crop information but also the status of the operating machinery, operating machinery parameters, and other information. Today, with the wide application of information technology, agricultural information refers to the information in agriculture and agriculture-related fields and to the process of agricultural informatization, such as the collation, collection, and dissemination of agricultural information. As such, the acquisition of agricultural information is important to the operation process.

Obtaining adequate agricultural information can reduce the loss of predictability in the process of crop production. In agricultural information monitoring, UAVs provide the advantages of high flexibility and a large monitoring range. Yan et al. used a small UAV with a camera to detect pericarp mold in a citrus warehouse [9]. They found that the mold was more sensitive to light at 625~740 nm, and the mold features were extracted via infrared 1.4R-G and binarized by Otus. A detection accuracy of 93.3% was achieved. This technique helps reduce the loss of tangerine peels during storage due to mold.

Obtaining adequate agricultural information can also increase agricultural production efficiency and production effects. Chlorophyll is an important substance in green crops and can indicate the health status of these crops. To accurately detect the relative chlorophyll content of summer maize, Ji et al. studied the responsiveness of the vegetation index in the soil and plant analyzer development (SPAD) value of summer maize at different spatial vertical scales [10]. A model for predicting the SPAD values of summer maize leaves based on UAV multispectral images obtained at different spatial scales was established. This model is valuable for quickly obtaining the chlorophyll content, monitoring the health status of maize plants, and guiding field management.

Adequate agricultural information can also prevent safety problems during operations. Although UAVs have extremely high flexibility, their stability is slightly inferior to that of other automated machinery. Discrete obstacles in farmland environments, such as trees and power lines, often pose a serious threat to the flight safety of UAVs. Therefore, the operating environment of UAVs often has relatively strict requirements. Wang et al. improved the original deformable detection converter (DETR), introduced a global modeling ability into the front-end ResNet, and established a nonlocal deformable DETR [11]. This improvement increased the value of the average precision of object detection (MAP) from 71.3% to 78.0%, showing good performance in detecting slender objects.

3. Conclusions

This Special Issue of *Agriculture*, entitled "Application of UAVs in Precision Agriculture", includes studies on the impact of UAV parameter selection for air spraying and the use of UAVs to monitor the quality of agricultural products. In the era of Agriculture 4.0, UAVs will be increasingly extensively applied. The Academic Editors of this Special Issue hope that this collection of research articles will significantly increase knowledge and further stimulate research in this key area for future agriculture, especially the application of UAVs in precision agriculture.

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