Chapter 9

Use of UAV in Agriculture

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Introduction

Unmanned aerial vehicles (UAVs) are autonomous aircraft capable of executing missions planned before takeoff or adapting to various scenarios based on evolving conditions during flight, all controlled and commanded from a remote location, even though they do not physically carry a pilot. These vehicles are generally referred to as "drones."

In contemporary contexts, UAVs are widely used in both civilian and military sectors. Although initially developed for military purposes, UAVs have found extensive application in civilian life, especially in recent years. UAVs are considered platforms onto which integrated systems, equipped with the latest technologies, have begun to be mounted, allowing them to discover new areas of application day by day.

This study examines the widespread use of UAVs in civilian areas, focusing particularly on the agricultural sector.

History of Unmanned Aerial Vehicles

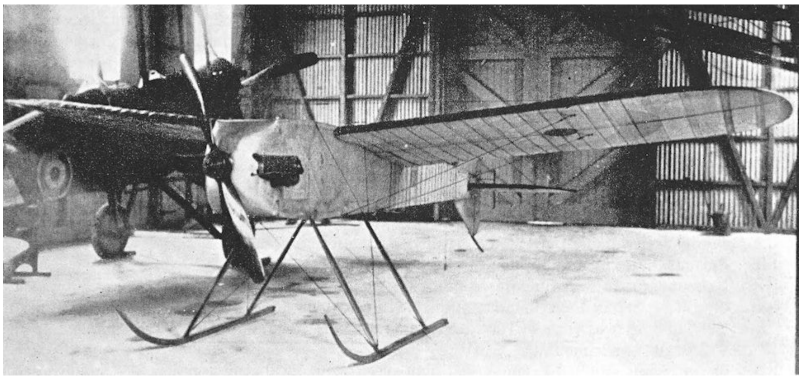
Unmanned aerial vehicles (UAVs) first emerged in the late 19th and early 20th centuries. The earliest examples of UAVs were, in fact, flying balloons. Although these balloons, armed with bombs, were directed toward specific targets with the aim of destroying them, they often failed to reach their intended targets due to uncontrollable weather conditions. Therefore, these early aerial vehicles differ significantly from today's UAVs (Stamp & Jeffrey, 2015).

The first examples of structures similar to today's UAVs began to appear during World War I. At that time, UAVs were used to gain superiority over enemy forces on the battlefield. These initial models lacked any control mechanisms and were launched from a ramp toward a designated target with the intent of destroying it. Although more effective than balloons, they often failed to achieve the desired effect due to difficulties in controlling them (Zaloga, 2011).

Figure 1
V-1 Flying Bomb

In subsequent years, advancements in electronics enabled the remote control of UAVs for the first time. This made it possible to control UAVs from a distance within certain limits (Flying Machines, 2024).

Figure 2
The First Radio-Controlled Aircraft: Aerial Target.



In the following years, UAVs equipped with mounted camera systems were used for reconnaissance and surveillance, transforming them into aerial vehicles that provide critical intelligence information.

Figure 3
Tadiran Mastiff UAV, which made its first flight in 1970

Since the early 21st century, UAVs have evolved into systems capable of remaining airborne for extended periods, enabling communication over long distances, minimizing radar visibility, and executing successful operations with advanced camera systems and munitions mounted on them (Baykar Tech, 2024).

Figure 4
Bayraktar Akıncı UCAV (Baykar Tech, 2024).

The Use of Unmanned Aerial Vehicles in Agriculture

UAV Use in Seed and Seedling Planting

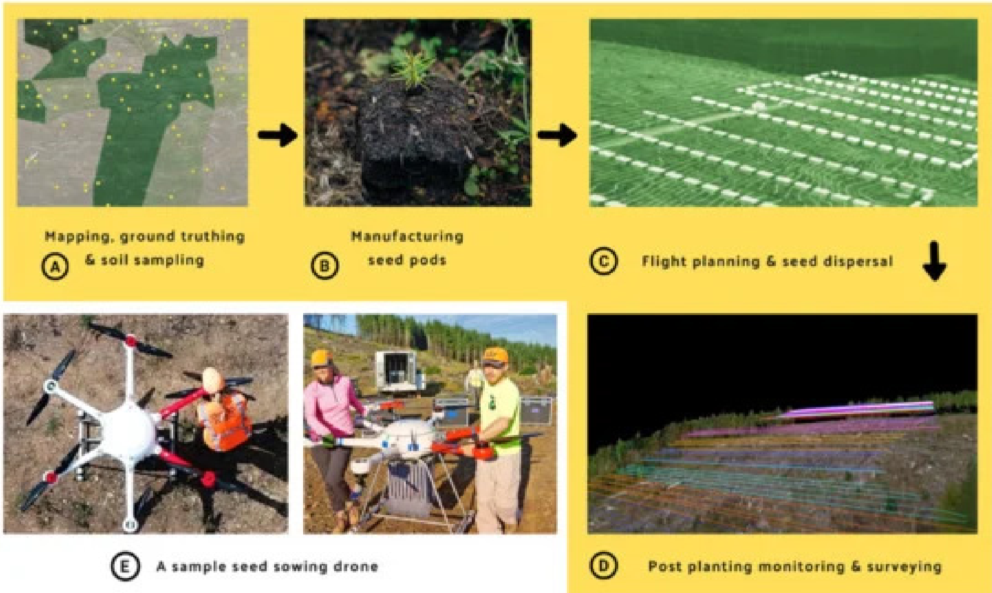
Today, the increase in human population, industrialization, rising consumption, and the lack of necessary measures in waste management have caused significant damage to ecosystems. Urbanization and the establishment of new residential areas, particularly in cultivated lands, along with intentional or accidental forest fires, have considerably reduced vegetation cover. Preserving forested areas and expanding their surface area are therefore essential for mitigating these negative impacts. Although these planting activities are typically conducted by the state or through public efforts organized by non-governmental organizations, planting in unsafe or hard-to-reach areas can sometimes be unfeasible. At this stage, the use of UAVs has recently made it possible to survey vegetation diversity, identify areas suitable for planting, and conduct aerial seeding to develop and expand forested areas (Mohan et al., 2021).

Figure 5
UAV-Assisted Seed Planting Process

Additionally, with the help of UAVs, low-altitude imaging and measurements over cultivated areas allow for the differentiation of planted seed and seedling types, as well as monitoring their growth. If any issues are detected at this stage, necessary measures can be taken within response timeframes to address potential problems (Buters, Belton & Cross, 2019).

Figure 6

UAV Seeding and Seed Planting Processes Assisted by UAVs (Courtesy of DroneSeed

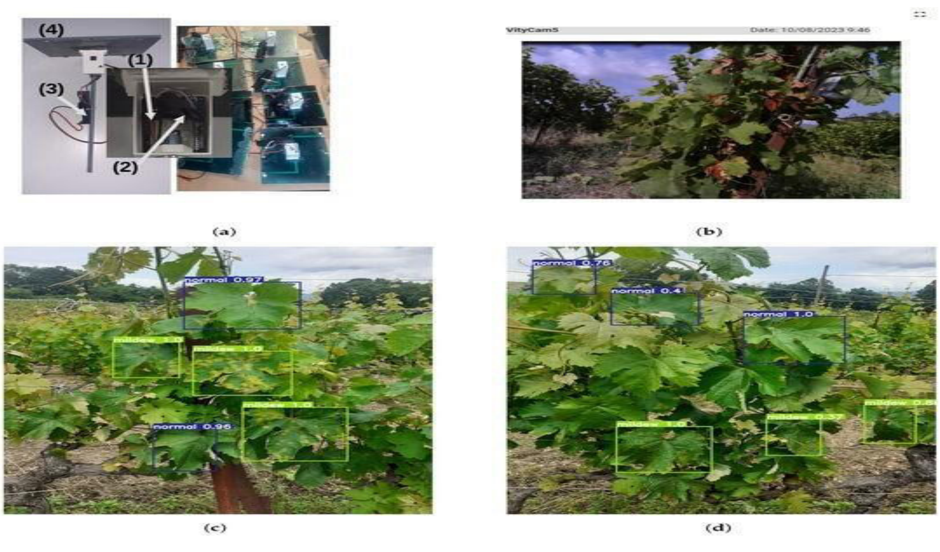


UAV Use in Detecting Crop Pests and Plant Diseases

In agricultural practices, crop yield can decrease, and plants may even be lost during the flowering and fruiting stages due to pests and diseases. Monitoring and identifying these issues early for timely intervention can increase yield and reduce production costs (Kılıç & Karakoyun, 2023). For this purpose, UAVs equipped with thermal, hyperspectral, and high-resolution cameras and sensors make it possible to sustainably monitor plant growth and health (Kontogiannis et al., 2024).

Figure 7

Plant Image Captured with UAV Assistance; System for Detecting Healthy and Diseased Plant Leaves (Kontogiannis et al., 2024).



UAV Use in Mapping

In sustainable agriculture, controlling weeds around plants is as important as managing plant diseases. The success of this control depends on the accurate and timely mapping of weeds, allowing weed control efforts to be conducted with minimal time, chemical usage, and cost. For this mapping process, UAVs are equipped with high-resolution cameras as well as multispectral cameras. These systems enable accurate classification and detection of weed species, facilitating effective mapping. The image below illustrates weed detection in a cornfield based on camera footage from a UAV (Gao et al., 2024).

Figure 8
Plant Image Captured with UAV Assistance; Detection of Weeds (Gao et al., 2024).

UAV Use in Pesticide and Fertilizer Spraying

In crop cultivation, combating harmful factors that damage plants is essential for increasing yield and reducing economic losses. Chemical control is the most widely used method in plant protection (Demir, 2015).

While mechanical sprayers have made it easier to control and eliminate these pests, unplanned and indiscriminate use of chemicals can harm plants, beneficial organisms around them, and the environment, leading to ecosystem disruption. Additionally, unregulated chemical application increases production costs and, most critically, endangers human health (Demir, 2015).

At this stage, UAV-integrated spraying systems enable targeted application of chemicals from low altitudes, minimizing environmental dispersal and chemical usage. UAVs can identify specific areas that require treatment, ensuring that chemicals are applied only where necessary. This method reduces the amount of chemicals used, thereby lowering spraying and production costs. Minimizing chemical release into nature also helps preserve the environment (Wei et al., 2024).

Moreover, UAVs can distribute fertilizer—crucial for plant growth—uniformly across cultivated areas. Similar to spraying, UAVs apply fertilizer within predefined boundaries directly onto plants, allowing for maximum yield with minimal fertilizer use. This targeted fertilization approach significantly reduces production costs. In Figure 9, trees were detected on the image taken from the UAV in a garden with apple trees.

Figure 9
Identification of Spraying Areas in an Orchard of Apple Trees Using UAV Assistance (Wei et al., 2024).

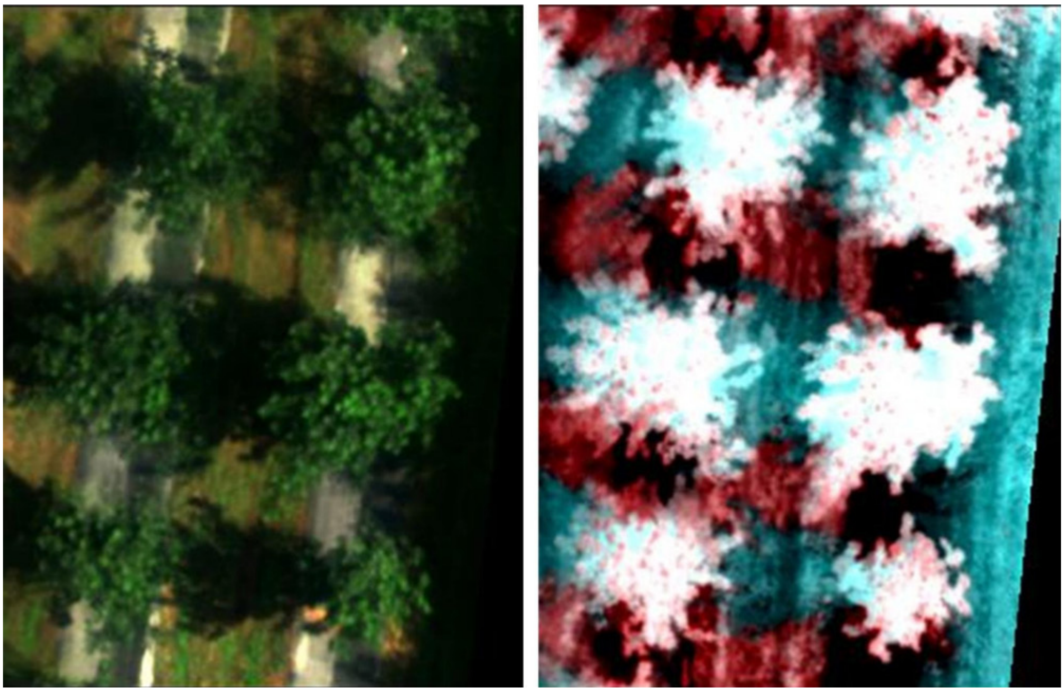
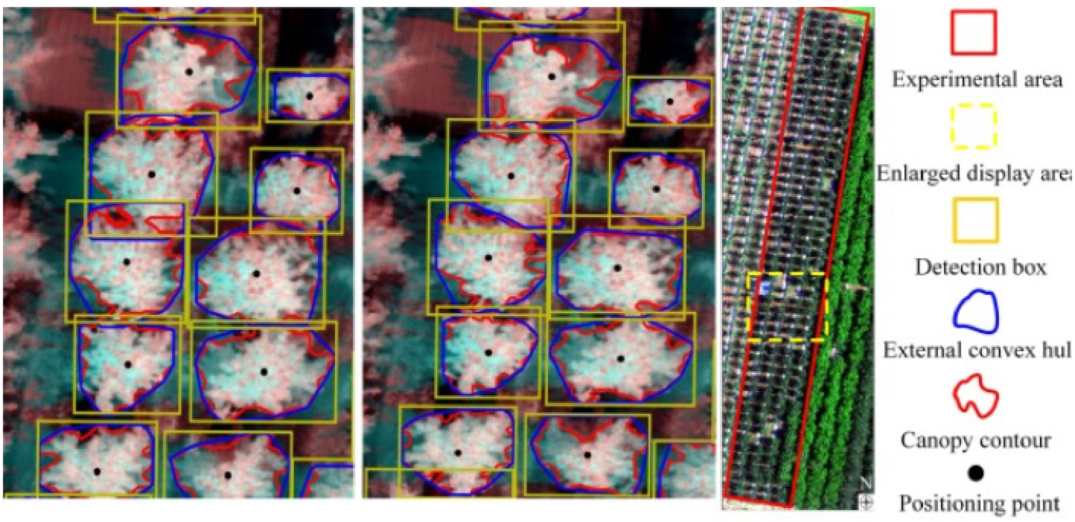
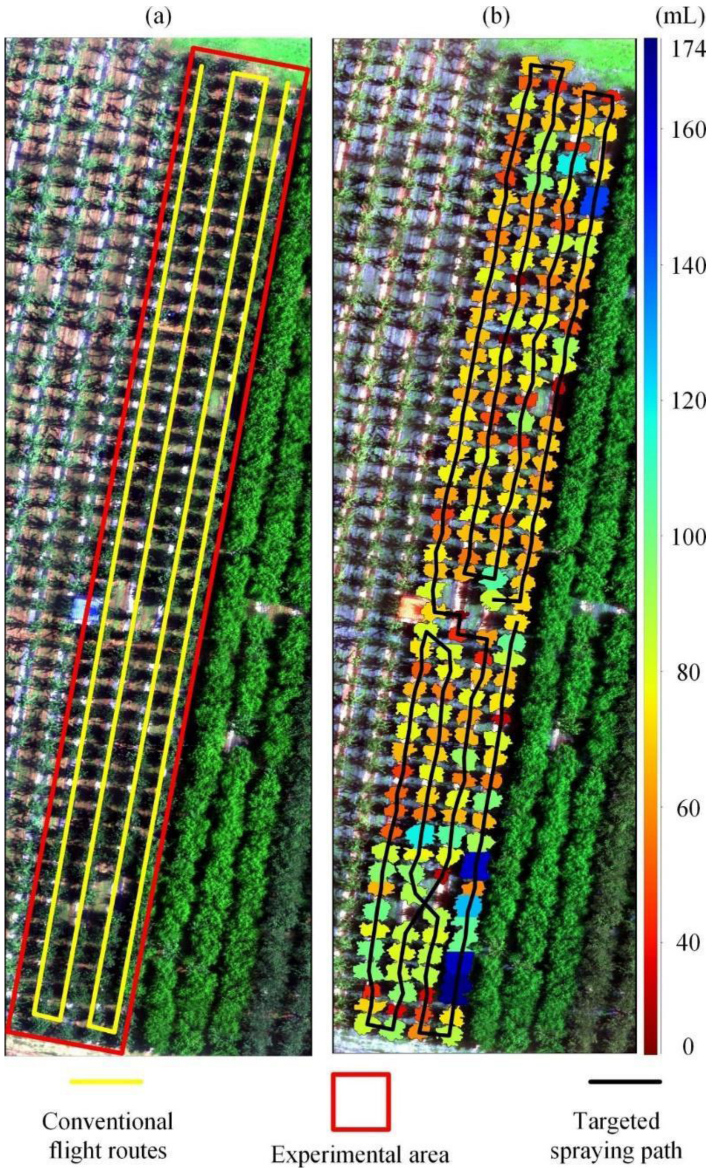


Figure 10
Identification of UAV Positions for Spraying Areas in an Orchard of Apple Trees Using UAV Assistance (Wei et al., 2024).



In Figure 10, the areas where the UAV will be positioned for spraying are identified. Finally, in Figure 11, the shortest flight path that the UAV will follow for spraying the entire area is planned. (a) shows the traditional flight path, while (b) illustrates the shortest path determined for spraying based on the study results.

Figure 11
Planning the Shortest Flight Path for UAV Spraying in an Orchard of Apple Trees (Wei et al., 2024).



UAV Use in Crop Yield and Harvest Prediction

Regular monitoring of plant growth and the ability to accurately predict crop yield and harvest in advance play a crucial role in management and the control and regulation of production stages. Predictions made using traditional methods may differ from actual values. Recently, UAV-based remote sensing systems have been used to predict yield. During key growth stages, such as flowering and fruiting, images captured by UAV cameras are processed using various image processing techniques and classifiers to estimate yield. Studies have shown that yield predictions based on UAV-derived images can accurately reflect actual production values (Feng et al., 2020; Shvorov et al., 2020).

Conclusion

Although UAVs were initially developed for military purposes and their advancements have largely been in this field, they are now extensively used in civilian sectors. One of the most common applications in these civilian areas is agriculture. UAVs are used across a wide range of tasks, from seed planting and plant protection to species identification and yield prediction. The benefits gained from these applications make a significant contribution to sustainable, efficient, and low-cost production.

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