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Practical application for Unmanned Aerial Vehicles (UAVs) commonly referred to as drones have progressed significantly in the recent years as the technology has improved in tandem with a fall in its cost. Interest from both consumers and businessmen in drones is growing with the new applications being developed rapidly for use across many industries including agriculture, one of the primary sectors which is expected to see sharp uptake of drone technology in the near future.

Information and Communication Technology (ICTs) is playing a vital role in addressing problems occurring in agriculture due to climate change alone are enormous. The need for the farming communities to adapt and become resilient is key to feeding the world's growing population. Harnessing the growth and transformative potential of ICTs are tremendous. The challenges faced by agriculture platform not only inculcate some of these challenges, but also accelerate the efforts to achieve the Sustainable Development Goals (SDGs) by 2030. Drones are used in various fields ranging from the military, humanitarian relief, disaster management to agriculture. A recent PwC report (PwC, 2016) estimates the agriculture drone market to be worth USD 32.4 billion. Based on particular project requirements drones can be equipped with

a range of image data sensors. The most established application based on drone-acquired image data is to assess the health of crop vegetation. Nowadays, drone technology is more and more often employed in insurance, with agriculture claims management being one of the key applications. Another, rather non-obvious application of drone imaging and mapping capabilities is counting and taking stock of herds of animals. Such an approach would lead not only to the improvement of dosage in the affected areas, but also to a reduction in the overall use of chemicals within the area. There are a number of applications of drone technology convergence with advanced image data analytics that can be utilized in the agriculture industry. Our recent estimations valued the addressable market for drone application in agriculture at USD 32.4 billion. Farmers has always needed accurate and up-to-date information on the health of their crops and the environmental condition of the land. Agricultural aircraft have been in use since the 1920s, while agricultural experts increasingly use satellites to assess crop health from the sky. UAVs are a natural progression from macro to micro, from large-scale to small-scale farms.

Drones haven't had a significant impact on agricultural practices until recently. From the ability to image, recreate and analyze individual leaves

on a corn plant from 120 meters height, to getting information on the water-holding capacity of soils to variable-rate water applications, agricultural practices are changing due to drones delivering agricultural intelligence for both farmers and agricultural consultants. Unfortunately, many of the promises being made to farmers by drone service providers simply couldn't deliver, even backed up by proper research yet. Until now air space controllers did not open segments of airspace above agricultural areas for commercial drone agricultural research to take place. The service providers with an open airspace to a specific flight height will also be able to use drones to provide better planting and crop rotation strategies and to provide a higher degree of all-around monitoring of how crops are progressing on a day-to-day basis in different parts of a given crop field, as well. In the coming years all of the possible uses for drones will be fleshed out by drone service providers and farmers itself. A boost in crop intelligence will make farms more efficient and help smaller operations compete with their more well-heeled Big Agriculture competitors. A widely-cited drone report released by the Association for Unmanned Vehicle Systems International predicts that the legalization of commercial drones will create more than €70 billion in economic impact such as revenues, job creation between 2015 and 2025, and that precision agriculture will provide the biggest piece of that growth. For now here are five drone agricultural applications already being implemented in the field.

Empowering local communities and fighting pests

The technology also has the potential to empower indigenous communities to document illegal occupations of their territories and natural resources as is described in this article. With UAV-gathered imagery of illegal logging and land occupancy government agencies can prioritize and speed up their inspection efforts ensuring that a week-long field inspection will collect enough evidence to justify government intervention.

Enhances Capacity Building

Awareness and education – or a lack thereof – presents another barrier to the adoption of UAVs in the developing world. While drones are relatively easy to use, farmers still need local language training and technical support before they get started, as well as up-to date information on the technologies

Harvesting coconut is becoming a difficult task since many of the trained workers are no longer working and the current generation is showing little interest in this job. Thus, the invention of new machines is becoming extremely necessary in order to revive coconut farming.

and legal status in their country. UAV operators need adequate access to electricity (for charging batteries) and the ability to obtain or craft spare parts. Processing drone data is another challenge: producing maps, 3D models, and other useful data outputs require considerable computing power, or Internet and mobile data that's quick enough to access cloud-computing services. Drone operators, farm workers and workers will need to develop methods of keeping UAVs functional in more remote areas.

Application of Drones

► 1. Mid-Season Crop Health Monitoring

The ability to inspect in-progress crops from about 100 meters height using Normalized Difference Vegetative Index (NDVI) or near-infrared (NIR) sensors is, thus far, the premier application for drones in farming. This was a task traditionally performed by often-reluctant college interns walking into the fields with a notepad. Drones from the present generation, allow for coverage of more surface area in a much shorter time stretch, as well as the capturing of data that cannot be seen by the human eye (like the NDVI or near-infrared). Moreover, it removes much of the human error aspect of traditional inventory work, though a physical inspection of an area of concern after viewing the imagery is still recommended

► 2. Irrigation Equipment Monitoring

Managing multiple irrigation pivots is laborious, especially for large growers with many fields spread out across large regions. Once crops like corn begin reaching certain heights, mid-season inspections of

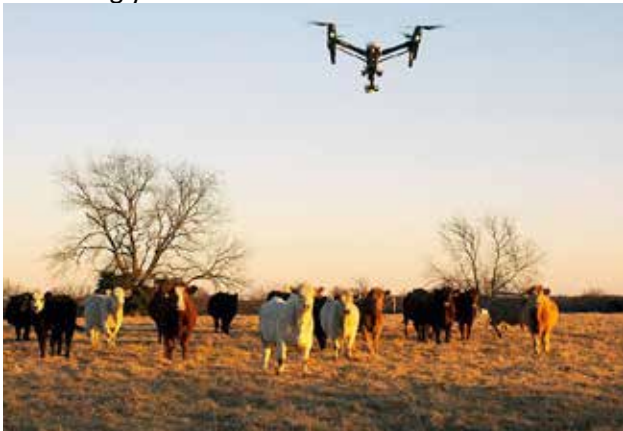
the nozzles and sprinklers on irrigation equipment that deliver the much-needed water really becomes a painstaking exercise.

▶ 3. Mid-Field Weed Identification

Using NDVI sensor data and post-flight image processing to create a weed map, farmers and their agronomists can easily differentiate areas of high-intensity weed proliferation from healthy crop areas growing right alongside them. Historically, many farmers haven't realized how pronounced their weed problem is until harvesting was performed.

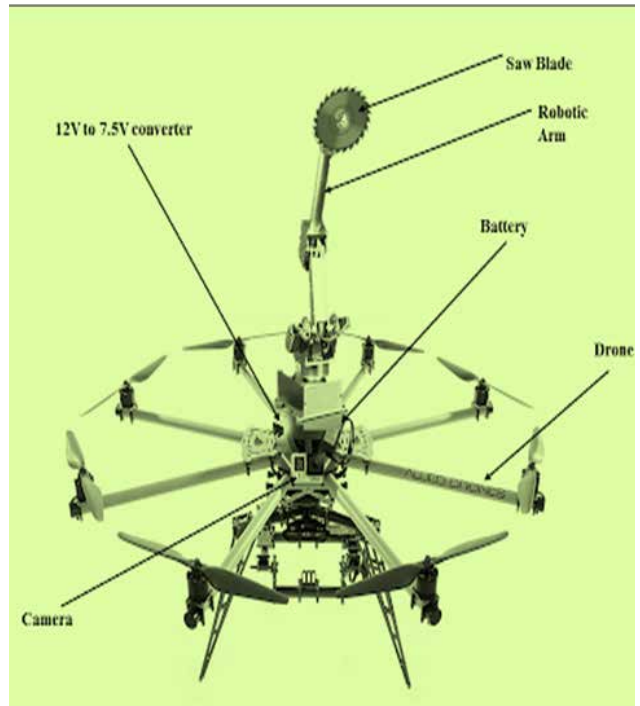
▶ 4. Variable-Rate Fertility

Though many will argue that ground-based inspections combined with satellite imagery, along with a dedicated grid soil sampling program is more practical for the purpose of refining Nitrogen, Phosphorus and Potassium applications in agriculture, drones do have their fit. A drone service start-up company in the US has used NDVI maps to direct in-season fertilizer applications on corn and other crops. By using drone-generated, variable-rate application (VRA) maps to determine the strength of nutrient uptake within a single field, the farmer can apply 300 kg/ha of fertilizer to struggling areas, 200 kg/ha to medium quality areas, and 150 kg/ha to healthy areas, decreasing fertilizer costs and increasing yield.



▶ 5. Cattle Herd Monitoring

Many growers during periods of depressed commodity prices made the call to diversify their farms by adding cattle or swine operations. Drones are a solid option for monitoring herds from overhead, tracking the quantity and activity level of animals on one's fields. They are especially helpful for night-time monitoring due to a human's eye's inability to see in the dark.



▶ 7. Health assessment

It's essential to assess crop health and spot bacterial or fungal infections on trees. By scanning a crop using both visible and near-infrared light, drone-carried devices can identify which plants reflect different amounts of green light and NIR light. This information can produce multispectral images that track changes in plants and indicate their health. A speedy response can save an entire orchard. In addition, as soon as sickness is discovered, farmers can apply and monitor remedies more precisely. These two possibilities increase a plant's ability to overcome disease. And in the case of crop failure, the farmer will be able to document losses more efficiently for insurance claims.

▶ 8. Coconut Harvesting Drone

Coconut production plays a key role in the economic and cultural upliftment of many of India's southern states. In fact the state of Kerala is widely known as 'land of coconut trees'. Harvesting coconut is becoming a difficult task since many of the trained workers are no longer working and the current generation is showing little interest in this whole concept. Thus, the invention of new machines is extremely necessary in order to save coconut farming. The goal of this project is to create a coconut harvesting drone which will revolutionize the coconut production in many of India's southern states particularly Kerala. The aim of this drone is

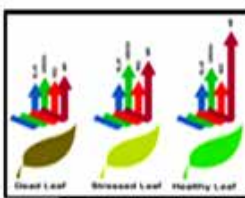
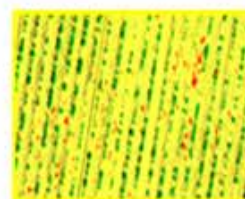
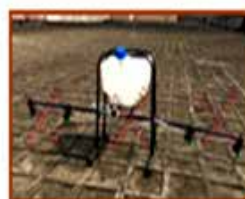
to cut ripe coconuts. This drone will be a manually controlled quad-copter, consisting of a camera and sensors to determine whether the coconut is ripe or not. Some of the technical challenges that we might face during the production of drone would be determining adequate amount of power for moving parts of the copter, finding appropriate sensor that can tell whether the coconut is ripe or not, and a capable robotic arm that can cut the coconuts.

Drones to boost agricultural production and help maintain food security

Subsistence farming using bullocks was largely replaced with large tracts of land ploughed by tractors and mechanized harvesters and using GMOs to enhance crop immunity. And now the next phase in the evolution of agriculture is a large-scale single crop unit that would give unprecedented output because drones would be deployed for multiple functions. With rapidly growing population, environmental degradation, global warming and the reduction in arable land, food security will be an acute issue and feeding the teeming population would require innovation in agricultural methods and the extensive use of drone technology. By 2050, the global population will be around 10 billion, and to avoid food shortage, agricultural production will have to be doubled.

Multiple applications

Apart from capturing aerial imagery, drones would also be used for sprinkling water and pesticides on the crops. This would save both time and wastage. Spraying using drones would be highly targeted and the drone would figure out and spray as per-requirements. Similarly, drones can be deployed to spray herbicides on the farms. This would be a highly efficient method as currently herbicides are sprayed over the entire length and breadth of the form, but using drones herbicides would be sprayed directly on the unwanted weeds in the farm. Other special types of drones can also determine the exact quantity of fertilizers that would be needed in the fields. This would not only save fertilizers but also maintain ecological balance, as less of ozone-depleting gasses would be emitted with a targeted usage of fertilizers. Using a machine known as Green seeker, sensors measure crop nitrogen deficiencies in real time and then predict yield potential for the crop using the agronomic vegetative index NDVI. Drones would benefit farmers and everyone engaged in the agricultural sector in numerous ways. Farmers would



Drone it's Applications covering all aspect using in smart agriculture

be able to save time, money, and increase their knowledge about the growth patterns of different crops. Simultaneously, increased productivity and environmental protection would be in tandem.

Challenges ahead

While the potential for drone use in agriculture is significant, there are still several notable impediments to their progression beyond the niche market they occupy today.

Difficult financial situation of many farms likely to hamper adoption

Agriculture remains a difficult, low-marginal business for many farmers, with government frequently assisting when adverse weather of

market condition arises. Despite their savings-potential, drones still require substantial capital investment and technical expertise to be acquired and properly function for many small or medium sized farms that are less likely to benefit from economies of scale. Generally drones are directly used by farmers in agriculture or cooperatives of farmers. Alternatively they are also used by drone company representatives who are hired by farmers

Strengthening farmer to be modernized

Global uptake of new technology requires adopting and modernizing production practices in order to obtain the best return on this investment. With over 56% of the workforce aged over 55 in Europe, digital skills are often lacking which means that additional investment in training is often required. As per the study revealed by United States Department of Agriculture, 73 % of farmers are using computers for business purpose and the remaining

39 % belongs to Smartphone and Agricultural work (Farm) accordingly.

If this UAV based surveillance system is applied widely in the near future, millions of farmers will be able to benefit from the acquisition of real time farm information. Farmers need not spend significant amount of time on acquiring farm data and will have access to disaster warning and weather information when a disaster event occurs. Nevertheless, the UAV technology is still not mature enough for large-scale application. More UAV research and development work is required, including the development of applications for fishing, poultry and farming enterprises .It is difficult to predict the future of UAV technology in agriculture, but there are many promising trends and pilot projects. Analyzing UAV data is likely to enable farmers to swiftly identify the movements of larger crop pests, from wild boar to elephants. Yet more uses for drones are likely to be dreamed up in the near future. ■

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