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SECOND PLACE STUDENT ESSAY

Popular press article with audience of producers, county agents, and anyone else interested in drones.

Drones: The Newest Technology for Precision Agriculture

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ABSTRACT Drones, or unmanned aerial vehicles (UAVs), have been used by the military since WWI for remote surveillance. In the last decade, farmers have begun using them to monitor their fields as well as aiding precision agriculture programs. There are estimates that 80 to 90% of the growth in the drone market in the next decade will come from agriculture. The ease of use and ability to specialize each system means there will be a UAV for every situation. The Federal Aviation Administration (FAA) regulation currently limits drone usage to recreational. Rules for commercial use are expected to come out in September of 2015. UAVs can monitor fields more often than satellites, take more detailed pictures, and are not obstructed by clouds. The different types of cameras can monitor data like photosynthesis rates or find where patches of weeds are in a field. As the technology gets better and the cost continues to decrease, drones will have wider use in today's farm fields.

Drones, or unmanned aerial vehicles (UAVs), were first introduced during WWI for enemy surveillance. They are small, radio-controlled airplanes that can be used to take pictures. Nowadays, their use has expanded to small-time hobbyists and is quickly expanding to use in agriculture. Military drones are much larger than ones used by civilians. Crop scouting drones are small enough to be brought to the field in the back of a pickup, often under 15 pounds. The economic impact in the few years after regulations are implemented is predicted to be around $13 billion and 7500 commercial drones by The Association for Unmanned Vehicle Systems International, with 80 to 90% of the growth in the market coming from agricultural use (Karst, 2012).

The two main designs for UAVs are fixed-wing airplanes and rotary motor helicopters shown in Fig. 1. Each of these has its own benefits. The fixed-wing drones are able to fly at a higher speed, 25 to 35 mph, while still taking pictures. It can cover 600 acres per hour (Patrico, 2013), which is how long the charge on the battery lasts. Fixed-wing airplanes have to be thrown or launched into the air and need a large flat area to land upon. A parachute can be used in confined conditions, but that will severely reduce the life of the airplane. Luckily, replacement parts are easily available if the fuselage gets cracked. Rotary motors are able to hover and focus in on specific problem spots in a field while sacrificing maximum speed. They have a little less battery life because they often have to run four engines or more. The takeoffs and landings can be done in more confined areas, so they are better for beginner flyers.

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Another aspect of the system is the ground control station. This is where the operator stands and monitors the flight and data coming from the drone. Some systems are simple enough to be operated from a smart phone. A number of different software programs are available to analyze the data. More important ones stitch together the separate images into one smooth picture and then can incorporate the image into GIS systems. Afterward, variable-rate applicators can use those pictures to find portions of the field that are low on nutrients or pressured by weeds.

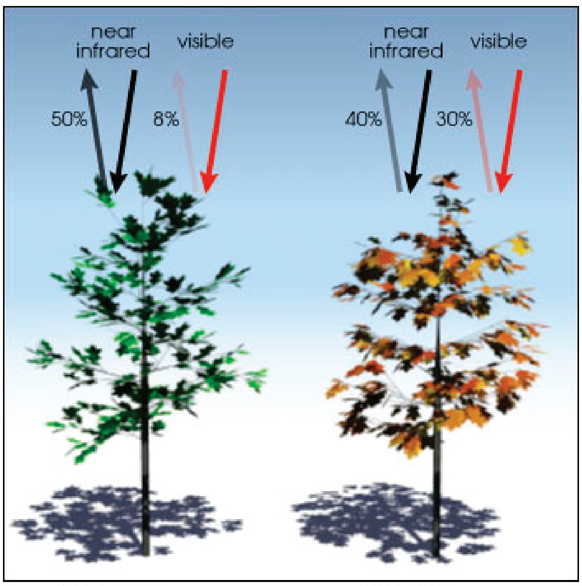
The drones can be manually flown, or pre-determined flight paths can be programed with GPS data. Learning to pilot the planes takes only a few hours, or they can be programed with one touch takeoff and will fly without any steering from the ground. Self-leveling programming can be installed to adjust for wind and to stabilize the images.

Drones are fairly cost effective and can pay for themselves in just a few uses. The cost of these UAVs can range from as little as $1000 for a starter system and can go up to $10,000 or $20,000, depending on the size of the machine and any extra cameras or features added. These systems are designed to have easily replaceable parts in case of crashes. Compare that to the several hundred dollars per hour it costs to have a piloted airplane fly over a field and it does not take long to cover the cost (Anderson, 2014). The money saved by targeting areas for fertilizer and pesticide applications can be figured into the price as well. Plus, it benefits the environment to not over apply chemicals to areas that do not need it.

FAA Regulations

Lack of regulations by the Federal Aviation Administration (FAA) has banned drone usage by commercial companies since 2007. This limits farmers to treating it more as a hobby and requires them to follow the rules laid out by the Academy of Model Aeronautics. Included in these rules are restrictions of flights within 5 miles of airports, keeping under 400 feet, and always being within line of sight of the operator. The privacy of the public is a big factor in regulations,

Fig. 1. Two types of unmanned aerial vehicles: Rotary copter (left) and fixed-wing airplane (right). Rotary copter image from Patrico, 2013. Fixed wing plane image from Precision Hawk (precisionhawk.com).



$$\frac{(0.50 - 0.08)}{(0.50 + 0.08)} = 0.72 \qquad \frac{(0.4 - 0.30)}{(0.4 + 0.30)} = 0.14$$

Fig. 2. Normalized difference vegetative index (NDVI) of a healthy plant (left) and stressed plant (right). The closer the NDVI is to one, the more near infrared light is being reflected, and the healthier the plant (Herring and Weier, 2000). Image from Robert Simmon.

and this makes agriculture an ideal market. Fields are usually in very sparsely populated areas so there is less chance for crashing into buildings or for people feeling spied on.

Plans are being made to have some rules on the table by September 2015. Some allowances have been given to universities and the military to research the possible uses of UAVs (Karst, 2012). Many companies are focusing on selling planes and parts while they wait for regulations that allow custom flights. Even once the rules go through, it is not like there will be an explosion of drone usage. It will be more of a slow implementation as the technology is experimented with and new problems arise.

Other countries have been using UAVs more extensively than the United States. Canada, Europe, Asia, and South America do not have as many regulations, so their drone use is more expansive. Japan in particular does a lot of spot applications of herbicides in rice paddies and in their less accessible highland fields (Donnerstein, 2013). The small size of the planes does limit the payload, so do not expect all chemical applications to be done by drones.

Benefits Compared to Current Monitoring

A lot of scouting these days is done by interns on foot. At ground level it is hard to cover the entire field and get a good look at the bigger picture. Especially late season, when the corn is over a person's head, it is nearly impossible to see the whole field on foot. Also, farms continue to get larger and more acres have to be watched. Once an entire field is covered by a drone, trouble spots can be identified and targeted for scouting on foot. Insurance companies can use drones to get a better idea on the extent of damage after a hail storm, easily determining whether a field has 70% compared with 90% loss (Donnerstein, 2013).

Currently the way to get aerial images of a field are either satellite images or possibly airplanes. These are limited by the resolution of their images and how often they fly over a field. The 15-cm resolution of UAV cameras is over 40,000 times better than the most commonly available satellite data and even 44 times better than the best commercial satellite images. Planes and satellites also fly above the cloud level and can be obstructed in bad weather. Drones have the advantage of being able to monitor a field every week throughout the growing season. Satellites have a week or two delay before the images are available. The drone operator runs on their own schedule and does not need to rely on the satellite flight path. This also means they have the flexibility to re-fly over trouble spots or move in for a closer look.

Types of Data Collected

With all of the interchangeability in drone systems, farmers are able to decide what features they want and how much they are willing to spend. The simplest systems come with a basic digital camera that only takes still images. A simple camera from Canon or GoPro can be mounted on a drone and equipped with different filters. Other types of cameras or sensors can be attached to suit many different kinds of uses. Orchard growers look more at the status of the crop instead of focusing on weed pressure like a cash crop farmer. Researchers will use more technical sensors that reach beyond the normal range of simple scouting.

A more advanced camera filter for crop scouting is one that takes near-infrared images. Healthy plants reflect both green and infrared wavelengths of light. When they are stressed from pest, nutrient, or water pressures, the types of light reflected changes and can be picked up by the cameras. On the pictures, healthy plants will appear bright red, while stressed plants or weeds will look darker. These can be used to calculate a normalized difference

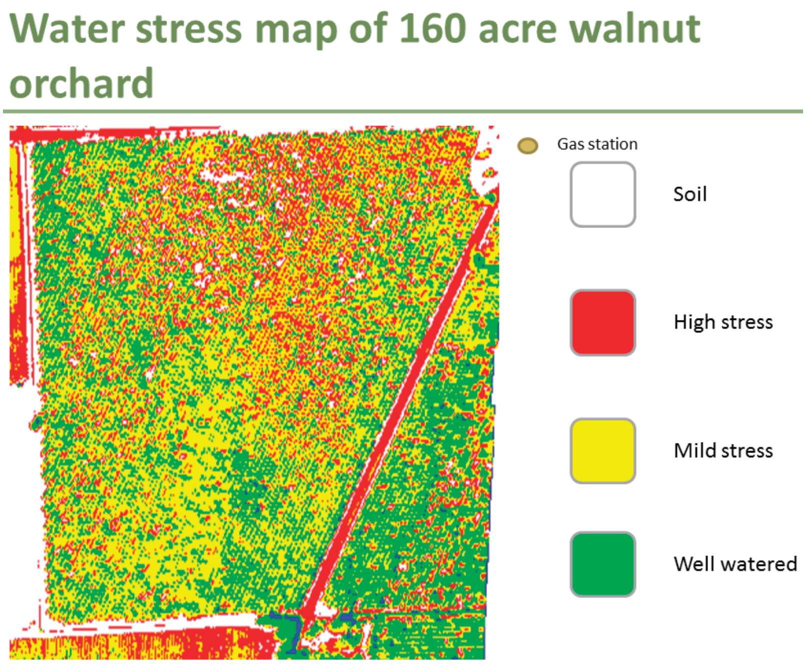


Fig. 3. A typical map constructed from aerial images taken from a drone showing the health of a walnut orchard (Image from Blank, 2014).

vegetative index (NDVI). The formula for NDVI is the ratio of near-infrared light (NIR) minus visible light (VIS) over near-infrared light plus visible light, as shown in Fig. 2.

$$NDVI = (NIR - VIS)/ (NIR + VIS)$$

The Trimble GreenSeeker is a common equipment mounted NDVI sensor, but it needs to be within 5 feet of the vegetation to get a reading (Malveaux, 2014). Figure 3 shows a map that can be created with software to show the areas of stress in an orchard.

Drones have other uses than just crop scouting. Livestock ranchers can use them to check up on cattle in a far pasture. Farmers using irrigation equipment can look out for problems without having to walk out on foot. On the business side, real estate agents can use drones to get pictures of property for sale. The cameras can also be used to determine soil types, organic matter levels, and soil moisture levels. The soil maps can be combined with variable rate equipment to adjust the plant population or fertilizer levels based on what the soil can handle. To do this with traditional soil samples would take a large number of samples to get the same resolution across the field, costing time and money. Soil moisture levels are used to adjust irrigation for field conditions depending on weather and wet spots.

Virginia Tech University is experimenting with UAVs to monitor airborne pathogens such as *Fusarium* or *Phytophthora* (Donnerstein, 2013). They use drones to take spore samples while they fly around in the lower atmosphere, then grow the samples out in a lab. Using these samples and looking at weather patterns lets researchers figure out where the spores are coming from and moving to.

Conclusion

Drones have many different uses for agriculture and more are being created every year. The flexibility of UAV systems along with the number of additional features means that there is something for every agricultural application. The cost is getting more affordable as more companies get into the market and the savings means the systems pay for themselves in a short time. Getting a whole field view from the air makes it easier to pick out problem spots and target them with precision agriculture systems. Weekly aerial images of a field can be combined with the yield maps at the end of the season to look for patterns and trouble spots. Farmers are already moving toward more auto-steer equipment and variable-rate mapping, and drones can easily be integrated into these programs. Once regulations are implemented, drones could become a commonly used tool for agronomists and farmers.

References

Anderson, C. 2014. Agricultural drones. MIT Technology review. http://m.technologyreview.com/featuredstory/526491/agricultural-drones/ (accessed 27 June 2014).

Blank, S. 2014. What drones and crop dusters can teach about minimum viable product. Harvard Business Review. http://blogs.hbr.org/2014/02/what-drones-and-crop-dusters-can-teach-about-minimum-viable-product/ (accessed 17 July 2014).

Donnerstein, J. 2013. Drones could change face of no-tilling. No-Till Farmer. http://www.no-tillfarmer.com/pages/Spre/SPRE-Drones-Could-Change-Face-of-No-Tilling-May-1,-2013.php (accessed 15 June 2014).

Herring, D., and J. Weier. 2000. Measuring vegetation (NDVI & EVI). Earth Observatory NASA. http://earthobservatory.nasa.gov/Features/MeasuringVegetation/measuring_vegetation_1.php (accessed 20 July 2014).

Karst, M. 2012. UAVs in agriculture: Rules of the sky. Entira. http://entira.net/news-insights/entira-insights/uavs-in-agriculture-rules-of-the-sky/ (accessed 12 June 2014).

Malveaux, C. 2014. Investigation the potential for drone use in agriculture. Louisiana State University Ag Center. http://www.lsuagcenter.com/en/communications/publications/agmag/Archive/2014/Winter/Investigating-the-Potential-for-Drone-Use-in-Agriculture.htm (accessed 1 July 2014).

Patrico, J. 2013. Choosing your UAV. DTN Progressive Farmer. http://www.dtnprogressivefarmer.com/dtnag/common/link.do;jsessionid=B16F299235D9B4463999BCB94425C186.agfreejvm2?symbolicName=/ag/blogs/template1&blogHandle=agequipment&blogEntryId=8a82c0bc3e43976e013f0fd4de9907f2 (accessed 18 June 2014).