The Future of Drones & Agriculture

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B.S. Electrical Engineering - Penn State 1985

Received private pilot certification in 1982 - 1,000+ hours as PIC

Lifetime aviation enthusiast flying both manned and model aircraft.

Involved in several technology startups since 1988

Founding member of Drone Imaging
About Drone Imaging

• The **FIRST** company in PA to receive FAA authorization to operate drones for commercial applications

• Serve markets including **agriculture**, quarry/mining, commercial construction/inspection and videography/local news

• Services use visible and multispectral cameras and sophisticated post-processing software to generate NDVI images, high-resolution geolocated photographs and 3D surface gradient maps.

• Our mission is to provide **SAFE, FAST, ACCURATE and COST EFFECTIVE** alternatives to traditional manned systems and aircraft.
The drone market is estimated to be an $8 billion market and agriculture is projected to be 80% of the total market.

The agriculture drone market includes: equipment, autopilot software, post-processing software, cloud processing and cloud storage.

Most common agricultural use for drones is for high-res visible spectrum photos, NDVI images and surface gradient maps.

A typical flight will take 500+ images, software stitched together into a single high-resolution image.
Two basic types of unmanned aerial vehicle (UAV) are used, rotorcraft and fixed wing.

Rotorcraft have vertical takeoff and landing (VTOL) capabilities and the ability to fly very slowly or hover making them very desirable for most applications. Battery life is limited to 20-30 minutes, limiting mission times.

Fixed wing aircraft cover more area in a single flight, but do not VTOL capabilities and carry smaller payload. Typical flight is 40-50 minutes.
Ground control software is used to program the drone to fly fully autonomous missions. The grid pattern, below, shows how the waypoints define the “mow the lawn” flight plan.

Over 500 geo-located images are captured on a typical mission.
Collecting Images

Tetracam ADC micro * 100m AGL * 22min flight time * speed-10m/s
photo every 2sec. * 515 pictures * coverage 45 acres
NDVI Imaging for Precision Agriculture

NDVI images show plant stress caused by:

- Nutrients
- Water Stress
- Disease / Molds
- Insect Infestation
- Overall Health Status
- Crop Damage and Insurance Claim
- Weed Infestation
- Soil Quality - Overlay on Veris Soil Map

NDVI images show changes in crop vigor sooner than visible images.
Leaf reflectance in the visible and near infrared band as an indicator of plant health.
The spectral graph shows that while a plant may still look green in the visible spectrum, it’s NIR spectrum has changed dramatically.

\[ DVI = \text{NIR} - \text{Red} \approx 0.8 \]

\[ DVI = \text{NIR} - \text{Red} \approx 0.2 \]
Multispectral Camera

Each pixel of a multispectral camera captures light in the red, green and NIR bands.
A multispectral camera captures light in the red, green and NIR bands.

**Tetracam ADC micro**

- Size: 3” x 2” x 1.25”
- Flat Spectral Response
- Weight: 90g
- Price: $3,250
The Normalized Difference Vegetative Index (NDVI) is calculated by comparing the red and NIR bands as shown in the formula.

\[
\text{NDVI} = \frac{\text{NIR} - \text{RED}}{\text{NIR} + \text{RED}}
\]
Collecting NDVI Images

NDVI images can be gathered by several means:

- Satellite Data
- High Altitude Data
- Low Altitude Data
- Ground Observation
An NDVI image can tell a lot about an area.
Visible and NDVI images

Multispectral images with visible mosaic for reference
NDVI data can be exported as Shapefiles or other formats for variable-rate spreader applications.
Data Overlays

NDVI data captured by UAVs is one of several tools to be used by growers.

NDVI maps can be overlaid with:
1. Veris soil maps
2. Shapefiles variable-rate spreader maps
3. Visible image mosaics
4. Harvest yield maps
5. Google Earth maps
6. GIS survey maps
Another software feature is to create surface gradient maps for grading and environmental engineering.
It is currently ILLEGAL to fly drones for commercial applications. While the FAA has been slow to enforce these laws, the fact remains that commercial operators need an FAA 333 exemption to operate legally and carry adequate insurance.

Currently the FAA is issuing exemptions for companies that meet their flight qualifications. Some of the requirements are:

- Must have a pilot in command (PIC) with current pilot’s license, valid medical
- Cannot fly above 400 ft
- Line of sight only
- Fight plans will need to filed prior to all flights
- Spotter required
- VFR conditions

FAA is working on a drone operator licensing referred to as Part 107 licensing.
The future of drones in agriculture is AUTOMATION. Several challenges need to be overcome for fully or even partially automating the process.

• Flight Planning

• Flying autonomous flights, changing/recharging batteries

• Upload images to 3rd for processing

• NDVI processing

• Technical issues, flying and maintenance
• Unmanned Aerial Vehicles and Systems offer a new tool set to growers and farmers to reduce costs and increase yields by minimizing the use of fertilizer, insecticides, fungicides and other chemicals, while improving overall plant health and crop yield.

• The significant benefits drones offer will make UAV’s ubiquitous in the farming community over the next several years.

• The rapidly advancing technology will work to improve the effectiveness and ease of use for drones in the years to come. However process of flight planning, imaging, post-processing and maintaining the drones will remain a significant undertaking.

• Drone Imaging is seeking strategic partners to gather images of crops in all phases of growth, with a variety of pathogens in various levels of vigor.