Drone Activities

Contents

Teaching Notes

These activities are designed to teach the process of drone data collection for agriculture.

Equipment/Software Required

- DJI Drone with RGB camera
- Hobby or Pro Subscription to DroneLink
- WebODM
- B4uFly App
- Drone Weather App ???
- Google Earth (or Maps)
- Handheld GPS?
- GIS?

Preparation

Develop a study area on the campus like a lawn area or ball field. Turf is similar to a crop and you can often see differences in plant health with a RGB camera. Keep in mind that agriculture commonly uses near IR sensors and lessons will be more realistic if you have access to a drone with this type of sensor. Keep in mind that you don't want to fly over people so the area needs to be open during class. Once you have a study area you can tune the activities around this area.

Drone Pre-flight Activity

Name _____
Period _____

Purpose

To learn the parts of the drone and inspect it for airworthiness. Learn how to clean the drone.

Materials

Maintenance Supplies

- Spare propellers
- Spare batteries
- Battery Charger (12 V if in the field)
- Landing pad for non-paved surfaces

Check that you have the following equipment on hand before you start cleaning the drone.

- ❑ Anti-static cloth such as a micro fiber cloth
- ❑ Small cleaning brush (for tight crevices) like a soft toothbrush
- ❑ Compressed air canister (air duster)
- ❑ Isopropyl alcohol. Better than water since it is non-corrosive and non-conductive.
- ❑ Lens cleaner and tissue

Hint: Put cleaning supplies in a small tackle box or plastic container. This way they are all together and ready for use.

Battery Care

- Don't charge the battery right after a flight because the battery's temperature may be too high. Avoid charging the battery outside of the stated charging temperature range.
- "Top off" the battery before flight.
- After charging is complete, disconnect the battery from the charger.
- Examine the charger regularly for damage to the cord, plug, enclosure or other parts. Never use a damaged charger.
- Fully charge and discharge the battery once every three months to maintain battery health. Note that some batteries will self-discharge to maintain the health of the battery.
- Label batteries with the date they went into service and a number (e.g.; 1,2,3). Log charges to track charge/discharge cycles.

Directions

If you clean the drone after every flight, you can expect a better performance. Otherwise, the grime and dirt buildups in the motor might prevent airflow and impact the efficiency of your drone. There is no doubt that drones can withstand harsh conditions and normal wear and tear. If you spend only a few minutes cleaning the drone, you can reduce the maintenance cost significantly.

Pre-flight

- ❑ Cleaning:
  - Outer shell and Props – blow off dust and wipe with alcohol and cloth.
  - Use canned air to remove debris from all those hard-to-reach spots, check where props attach to motors.
  - Remove the battery and blow out the compartment.
- ❑ Inspect the outer shell and other components for damage.
- ❑ Check condition of propellers before and after every flight. Make sure there are no bent blades or cracks.
- ❑ Check props to ensure that they spin freely. If props are removable check to see that tey are properly fastened.
- ❑ Check motors for debris and obstructions
- ❑ Check landing gear condition. Make sure the legs and feet of the unit are not bent or cracked, and that all rubber shock absorbers are intact. If the landing gear retracts test this function
- ❑ Inspect the camera gimbal for damage.
- ❑ Camara cover removed (if preparing for flight)
- ❑ Camera lens free of dust or dirt. Clean with camera lens cleaner and lens tissue.
- ❑ Memory card installed.
- ❑ Controller charged.
- ❑ Mobile device charged.

Batteries

- ❑ Inspect battery for damage or swelling. Discard (safely) damaged batteries.
- ❑ Use a fully charged battery. If a battery is idle for a long time, its performance might be affected.
- ❑ Don't remove or install the battery from the aircraft when it's turned on.
- ❑ Check the status of the battery after powering on the aircraft. Keep an eye out for app alerts during flight.
- ❑ Observe temperature restrictions on battery use. Typically, in the range of $0\ ^\circ$ to 100°F. Follow the stated temperature for battery use for your drone.
- ❑ If you fly in high temperatures above 40°C(104°F), keep an eye on battery temperature. Land immediately if the battery exceeds the recommended temperature.
- ❑ Pre-heat your battery to 20°C(68°F) when the temperature is lower than 10°C(50°F).

Test Flight

- ☐ Before a mapping mission it is a good idea to take-off and land just to check that the drone is flight worthy. If the test flight does not look right do not fly a mapping mission. Note this will reduce flight time by about 1 minute or you can install a fresh battery.
  - Start the drone
  - Take-off and hover at 4'. Observe the drone.
  - Land

Questions

1. Why is it important to clean the drone?
2. Why is a pre-flight inspection important?
3. What are you observing in a test flight?
4. Why is important to maintain batteries with their operating temperature?

Mission Planning – Ground Sampling Distance Activity

Name _____
Period _____

Purpose

To understand the relationship between the camera, flight altitude and image resolution.

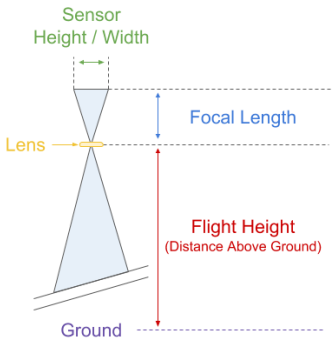
Materials

- Drone camera specifications

Background

Image resolution is important as high resolution images are very detailed and files are quite large. Low resolution images may not give enough detail for analysis or image processing (stitching). Image resolution comes at a cost since high resolution images cover a smaller area you will have many more images for a given area and processing will take longer.

Consider the camera on your cell phone. Take a photo of an object from 10 ft and a second from 30 feet. Compare the detail in the two photos. Zoom the second photo to the same scene as the first.



To calculate the Ground Sampling Distance (GSD) you need 3 parameters for the drone camera.

- Sensor Width (mm) = width of the drone camera's sensor
- True Focal Length (mm) = The true focal length of the drone's camera (in mm).
- Image Width (pixels) = Number of pixels in the drone camera's image resolution. e.g. 5472

To compute the area of the image you will also need the image height (pixels).

For example:

	DJI Mavic Air 2	Your Drone
Sensor Width (mm)	6.4	
True Focal Length (mm)	24	
Image Width (pixels)	4000	
Image Height (pixels)	3000	

The fourth parameter is the Flight Height (m). Generally assume this to be the drone flight altitude. Note the units are in meters. Calculate the GSD using the formula. Divide feet by 3.28 to convert to meters.

GSD (cm/pixel) = (Sensor Width(mm) * Flight Height (m)) / (Focal Length(mm) * Image Width(Pixels))

To calculate the image area you will need the image height. Use the formulas:

Area Width (m) = Image Width (pixels) * GSD / 1000

Area Height (m) = Image Height (pixels) * GSD / 1000

For example, if the Mavic Air 2 is flown at 150 meters the GSD will be 1.0 cm/pixel. The image area will be 4 meters x 3 meters.

High Resolution

Low Resolution

High Resolution

Low Resolution

Directions

1. Enter the camera specification for your drone in the table above.
2. Compute the GSD for a flight at 100 meters.
3. Compute the image area for this flight.

Questions

1. Flying higher will result in higher / lower image GSD?
2. Flying lower will require more / less images to cover the same area.
3. What is the GSD for your drone when flying at 400 feet? _____ cm/pixel
4. What will the image area be for your drone when flown at 400 ft? _____ m x _____m
5. Convert the resolution in cm/pixel to inches per pixel. Hint: 1 inch=2.54 cm. _____in/px

Useful Information

1 meter = 3.28 feet
1 acre= 4046 square meters
1 inch=2.54 cm

Mission Planning – Airspace Activity

Name _____
Period _____

Purpose

Learn to use latitude and longitude coordinates. Become familiar with airspace restrictions.

Materials

- PC or Mobile device (load the app B4UFLY).

Directions

Open the app https://b4ufly.aloft.ai/

For the following locations determine if you can fly or what restrictions you may have.

In search type in the latitude and longitude

	Location (latitude, longitude)	Restrictions
1	40.5, -122.31	
2	39.0, -121.4	
3	36.5, -116.9	
4	37.1, -120.8	
5	Your school	

Questions

1. What type of restriction was found at location #1?

   _____

2. What type of restriction was found at location #2?

   _____

3. What type of restriction was found at location #3?

   _____

Mission Planning – Area Inspection Activity

Name _____
Period _____

Purpose

To determine the potential hazards for flight and determine the location of a safe take-off and landing zone. In particular look for power lines, trees, towers, and buildings that would be in your flight path. Also look for people so you can avoid over flight. Remember that you need to keep the drone in a visual line of sight.

Materials

- B4Ufly App
- Google Map
- OK to Fly App

Directions

Flight Area

- ❑ Review your study area using Google Maps (satellite view).
- ❑ Inspect takeoff and landing areas for clearance from people, trees, powerlines, buildings, and other obstructions.
- ❑ Plan your route of flight from the takeoff/landing zone to the study area
- ❑ Check for terrain and other obstructions
- ❑ Determine where to land safely in an emergency (ex. low battery, loss of control signal)
- ❑ Drone can be kept in visual line of sight (VLOS)

Airspace

Use the B4Ufly app to check the airspace https://b4ufly.aloft.ai/

Weather

Use the OK to Fly app to check weather https://oktofly.com/

- ❑ Wind within allowable limits
- ❑ Drone flight will be clear of clouds and fog

Questions

Mission Planning – Flight Planning Activity

Name _____
Period _____

Purpose

To plan a mapping flight with Drone Link

Materials

- PC with internet access.
- Dronelink account

Directions

1. Open Dronelink.

Questions

Fly the Mission Activity

Name _____
Period _____

Purpose

Materials/Equipment

Directions

1. Preform the preflight check.
2. Review the drone controls.
3. Open the mission in Dronelink on the mobile device.
4. Start the mission.
5. Observe the drone and be prepared to assume manual control. Use Return to Home (RTH) if needed.
6. Remove the microSD card, clean the drone, and store.

Questions

Download Images Activity

Name _____
Period _____

Purpose

To download and organize images from a flight.

Materials

Directions

1. Insert the microSD card into the reader. NOTE: how this is done will vary with the computer hardware. Some of the options are:
    a. If the computer has a SD card slot use an microSD adapter (most MircoSD cards come with these) and insert into the slot.
    b. You may use an USB adapter that accepts the MircoSD card.
2. Create a folder for images if this is your first flight.
3. Create a sub folder for this flight. Use a consistent naming convention for your flights. Include the date in the folder name in the format YYYY-MM-DD. Include the location of the flight in the filename. For example “2022-03-01 Miller Ranch”.
4. Copy the images from the MicroSD card to the folder. Note the date/time of the image files. This will help you separate different flights.
5. Explore the images to be sure they include your flight.
6. Remove any extra images usually at the beginning or end of the flight.
7. If the images are OK, delete the images from the MicroSD car.

Questions

1. What was the folder name you choose?
2. How many images did you copy?
3. How big are the images (each)?

Photo Stitching Activity

Name _____
Period _____

Purpose

To process images from a flight into a single image using WebODM.

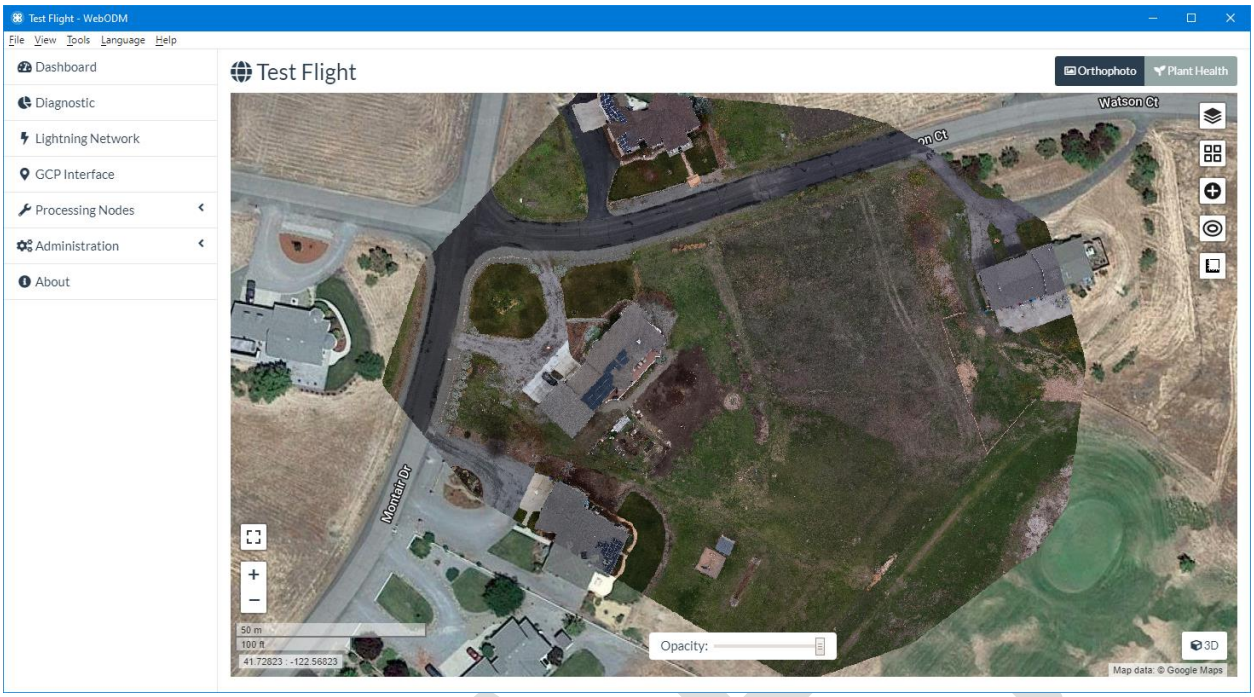
Materials

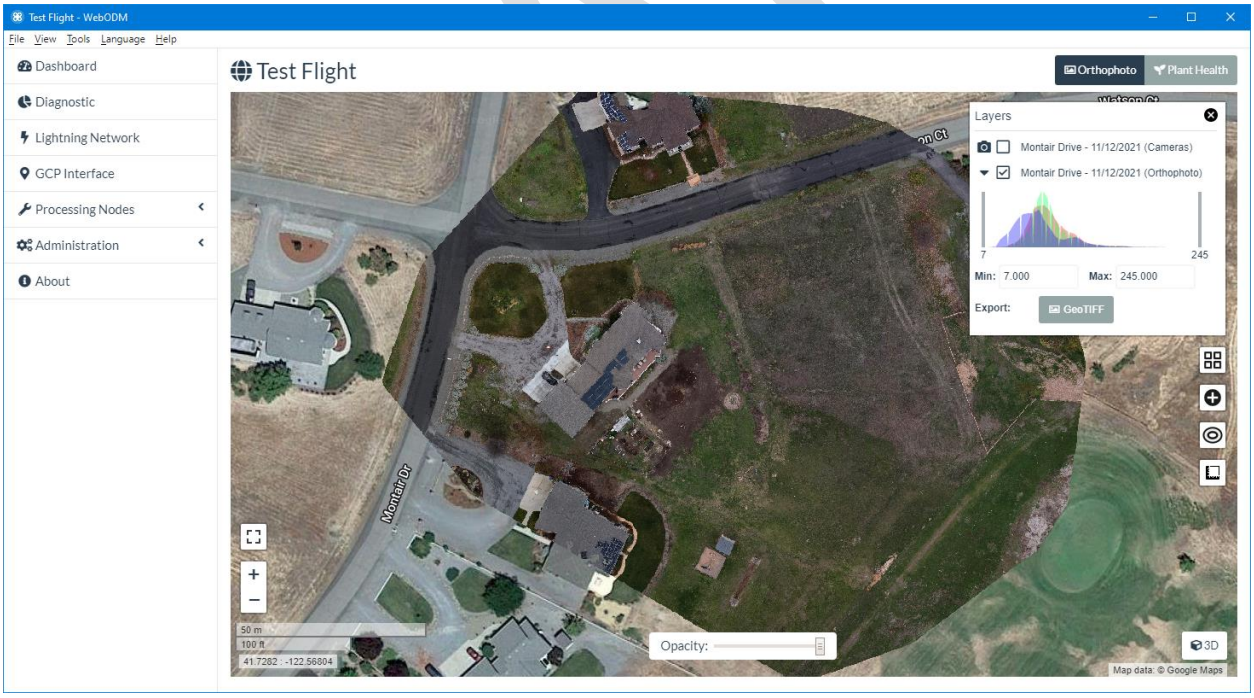
Directions

1. Open WebODM
2. Click on Add a Project. Give the project a descriptive name (like the folder naming convention you use for the images.
3. Click on Select Images and select the files from the flight folder.
4. Choose the processing node. Normally this will be the node on the local computer.
5. Choose the fast ortho option as a starting point.
6. Choose no to resize images.
7. Click on Review then on Start Processing. Wait for it! Depending on the speed of the computer this may take a while.
8. When the processing is complete. Click on View Map.
9. Click on the layers icon.
10. View the image locations by checking the cameras checkbox.
11. Turn off the locations by unchecking the cameras box.
12. Save the resulting image to the folder with the flight images. To do this click Export as a GeoTiff.

Questions

1. How many images were uploaded?
2. How long did the processing take?
3. What was the size of the resulting orthophoto?


Test Flight - WebODM
File View Tools Language Help
Dashboard
Diagnostic
Lightning Network
GCP Interface
Processing Nodes
Administration
About
Test Flight
Orthophoto
Plant Health
Watson Ct
Montair Dr
Opacity:
3D
Map data: © Google Maps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Plant Health
Layers
Montair Drive - 11/12/2021 (Cameras)
Montair Drive - 11/12/2021 (Orthophoto)
7
245
Min: 7.000
Max: 245.000
Export:
GeoTIFF
Montair Dr
Opacity:
3D
Map data: © Google Maps

VARI / NDVI Processing of Images Activity

Name _____
Period _____

Purpose

To demonstrate how an image can be enhanced to better show plant health.

Materials

- WebODM
- Stitched image

Background

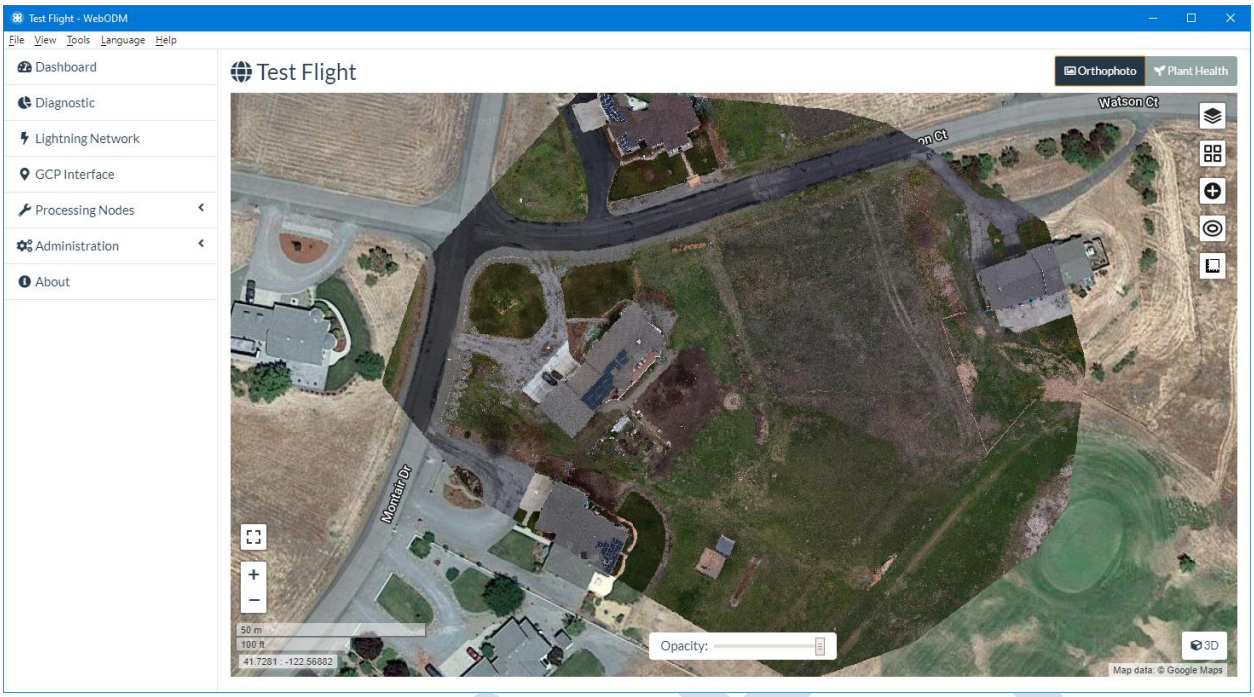
VARI and NDVI are processing techniques that use two bands to create a single band image (black & white images are one band images). The resulting image is then commonly rendered in color so the differences can be seen.

VARI uses the red and green bands. NDVI uses the near infrared and red bands.

VARI processing is a method of image processing that enhances differences in plant health. It uses RGB images.

Directions

1. Open WebODM
2. Locate the assigned flight in the dashboard
3. Choose View map
4. Click on Plant Health
5. Change the algorithm to VARI
6. Drag the bars to the middle to enhance the image. Experiment to achieve the highest contrast.
7. Save the resulting image to the folder with the flight images. To do this click Export as a GeoTiff.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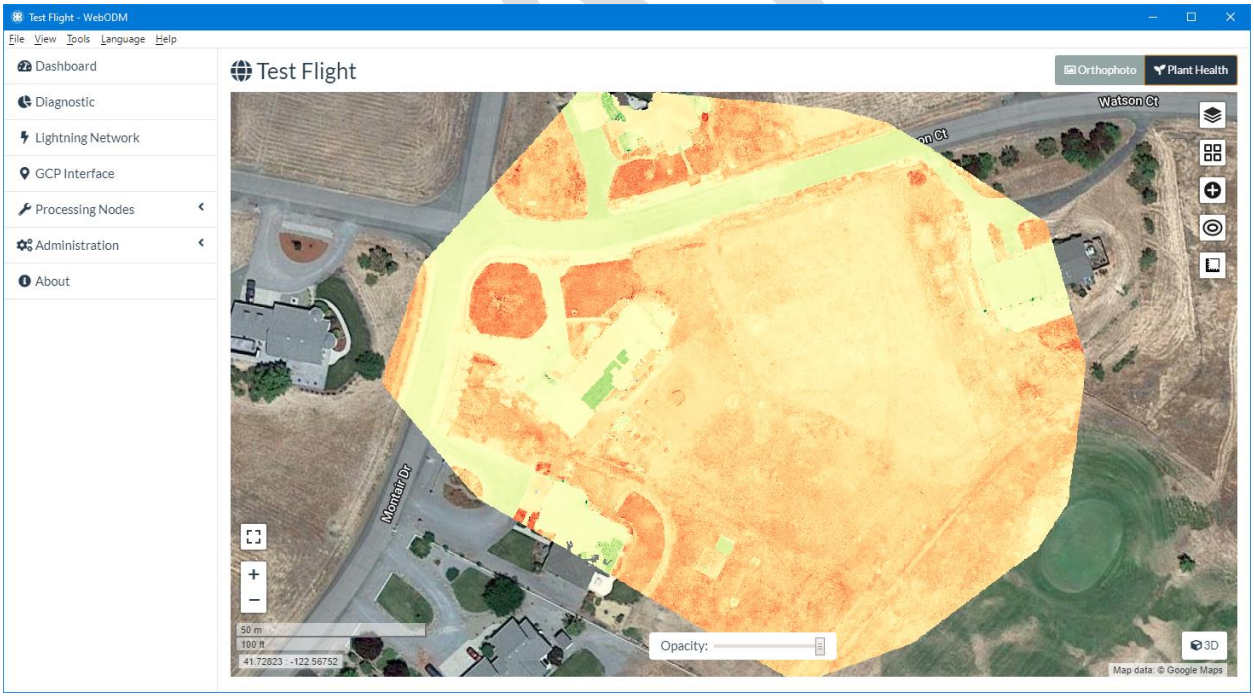
Plant Health
Watson Ct
Montair Dr
Opacity:
3D
Map data: © Google Maps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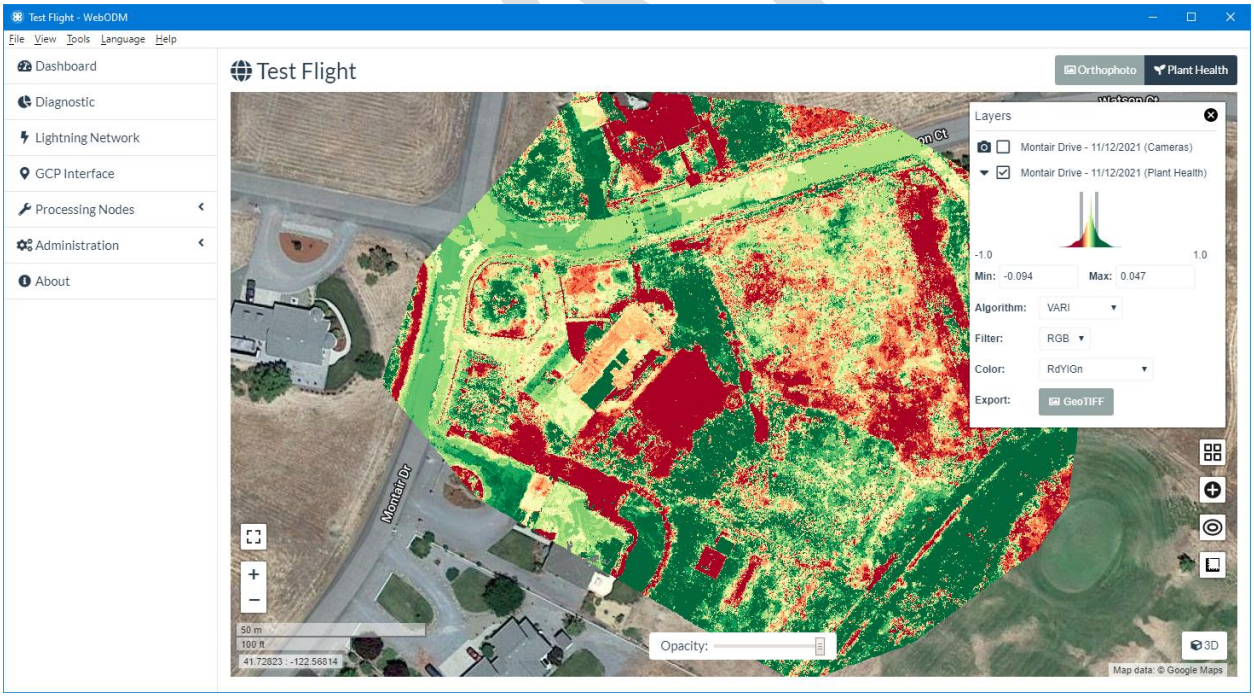
Plant Health
Watson Ct
Montair Dr
Opacity:
3D
Map data: © Google Maps



Questions

Describe how a VARI image is processed

Area Measurement Activity

Name _____
Period _____

Purpose

To use an orthophoto to measure and area.

Materials

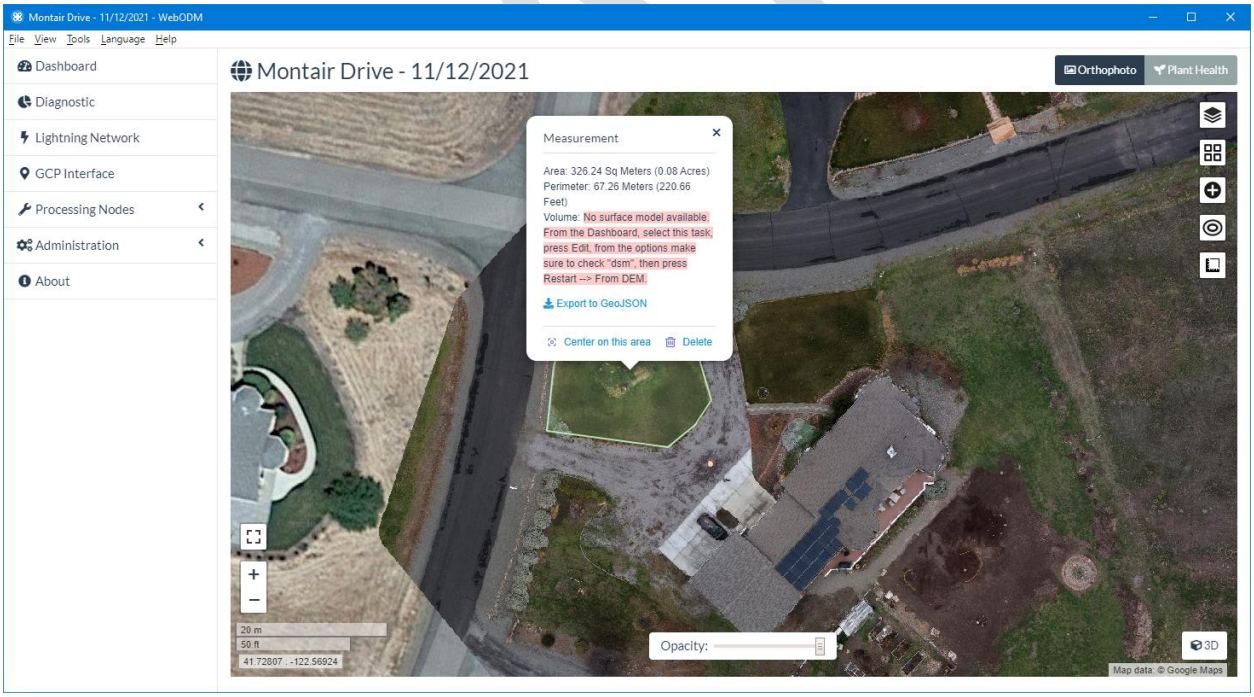
- WebODM
- Stitched image

Directions

1. Open a flight in WebODM
2. Choose the orthophoto view
3. Select an area of interest
4. Choose the measurement tool
5. Click on the boundaries of the area you want to measure. Zoom in to get the best positioning.

Questions


Montair Drive - 11/12/2021 - WebODM
File View Tools Language Help
Dashboard
Diagnostic
Lightning Network
GCP Interface
Processing Nodes
Administration
About
Montair Drive - 11/12/2021
Orthophoto
Plant Health
Measure volume, area and length
Last point
41° 43' 39.67" N / 122° 34' 10.49" W
41.727685 / -122.569580
Path distance 62.67 Meters (205.59 Feet)
Area 326.24 Sq Meters (0.08 Acres)
Cancel
Finish measurement
Opacity:
3D
Map data: © Google Maps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Lightning Network
GCP Interface
Processing Nodes
Administration
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Montair Drive - 11/12/2021
Orthophoto
Plant Health
Measurement
Area: 326.24 Sq Meters (0.08 Acres)
Perimeter: 67.26 Meters (220.66 Feet)
Volume: No surface model available. From the Dashboard, select this task, press Edit, from the options make sure to check "dsm", then press Restart --> From DEM.
Export to GeoJSON
Center on this area
Delete
Opacity:
3D
Map data: © Google Maps


Montair Drive - 11/12/2021 - WebODM
File View Tools Language Help
Dashboard
Diagnostic
Lightning Network
GCP Interface
Processing Nodes
Administration
About
Montair Drive - 11/12/2021
Orthophoto
Plant Health
Opacity:
3D
20 m
50 ft
41.72801 : -122.56936
Map data: © Google Maps

Interpretation Activity

Name _____
Period _____

Purpose

To review a drone image and locate problem areas.

Background

The health of a crop is dependent on many factors. Some of the common factors are:

- Differences in soil type
- Irrigation non-uniformity
- Differences in fertilization
- Pests or disease
- Saline soil areas

Some of these causes will create recognizable patterns in the image.

Materials

- WebODM
- Stitched image (field or turf area)

Directions

1. Review the image. Do you see differences in the color of the crop?
2. Look for patterns. What do you think is causing the patterns?
3. Mark some areas for study.

Questions

Field Checking Activity

Name _____
Period _____

Purpose

To use an image captured by a drone to locate problem areas on the ground. Once located determine the cause.

Materials

- Stitched image
- Software to view geotiff on mobile device ?? https://play.google.com/store/apps/details?id=com.custommapsapp.android
-

Directions

Questions

GIS Layer Activity

Name _____
Period _____

Purpose

To see how drone imagery can be loaded into a GIS for analysis and long term comparison.

Background

GIS is a tool to storing and analyzing geo referenced data. Data is imported in "layers". Image data is in "raster" format and will normally be a solid layer (cannot see through it). Layers like roads and field boundaries are "vector" data. Vector data is made up of lines or points and is transparent (you can see what is behind it).

Materials

- PC with QGIS or ArcMap
- Several stitched images of the same area
- Several vector files of the area

Directions

1. Load the layers
2. Note that images are opaque and must be on "bottom" or to the back
3. Activate the vector layer(s).

Questions

Terms

Like any technology, drone and remote sensing have terms that must be understood to use the technology.

Term	Meaning
3D Mesh	A type of digital recreation system, often used with Building Information Management (BIM), that overlays 3D point clouds with reference points in X, Y and Z axes to create a more fully form representation of an area and/or objects.
Above Mean Sea Level (AMSL)	The altitude relative to a standard mean sea level geoid.
Above the Takeoff Altitude (ATO)	The altitude relative to the place a drone started its motor just before takeoff.
Accelerometer	Measures the drones orientation relative to earths surface. It monitors the 3D acceleration force on all 3 axis (X, Y, and Z). This provides speed, direction, and altitude change of the drone.
AGL	Above Ground Level. This measures the actual altitude between the ground and your drone.
Airborne Sensing	Remote sensing from an airplane. (Related words: airphoto, aerial)
Analogue	This is the opposite of DIGITAL. It refers to things that aren't made up of numbers. A photo taken with a film camera would be an analogue picture. A photo taken by a digital camera would be defined in terms of zeros and ones and would be considered digital. (Related word: digital)
Application	The end purpose for which remote sensing is used. Most often remote sensing is used to measure, map or monitor features of our environment.
ATC	Air Traffic Control.
Background Map	A visual 2D map of a region featuring landforms, roads, etc., onto which additional data is layered, also referred to as a base map.
Backscattering	Energy, when hitting a target, can be scattered in many directions. The part of the energy that is scattered back in the exact direction where it came from, is "backscattered". (Related word: reflection)
Base Map	(see Background Map)
BVLOS	Beyond visual line of sight.
Bystander	Anyone who isn’t directly associated with the drone operation.
Ceiling height	The maximum adjustable vertical height that the drone can fly to within the allowable working area.
Check Point	A surveyed point on the ground used to verify the accuracy of photogrammetric outputs. These includes DSMs, point clouds, 3D mesh, orthomosaics and DTMs.
Classification	When image pixels are the same color, or nearly the same color, an image "classification" computer program can recognize this and group such pixels together. Such a grouping is called a "class" and the process of doing the grouping is called "classification". The remote sensing researcher then has the challenge of identifying just what each "class" represents in the real environment (pine trees? pavement? shallow water? dry grass?). (Related word: classes)
COA	Certificate of Authorization. This FAA (Federal Aviation Administration) permit allows drone operator to perform additional, specific operations.

Term	Meaning
Composite Image	We can make a "composite" image by selecting the most appropriate parts of other images. For instance, we could take only the cloud-free parts of many images to make a "composite" image of all of Canada showing no clouds at all. It would not be a realistic scene, since we always have some clouds, but it would show all of Canada without allowing cloud cover to mask parts of it. (Related words: combining, mosaic)
Contour Map	A topographic map that delineates surface elevation using contour lines.
Detection	If you are detecting something, you are trying to determine if it is there. This could be done using your senses or by using instruments. Once it is found, it has been detected. (Related words: sensing, discovery, detect)
Digital Analysis	If you have a digital satellite image, then it's useful to analyze it digitally. Special computer programs are available for this. Such programs can stretch and distort a digital image to make it fit a map, they can enhance it to make it show some features more clearly, they can classify the image into categories which contain similar features, and much more. (Related words: image analysis, classification, enhancement)
Digital Data	Information that is made up of numbers is digital data. Telephone numbers are digital data, so are the percentage scores on your last test. So are digital images from satellites. The opposite of digital is ANALOGUE. (Related words: digitized, analogue)
Digital Elevation Model (DEM)	A 3D display in form of a raster grid that features the bare earth, removing all natural and artificial features.
Digital Surface Model (DSM)	A 3D display of an area that includes the tops of buildings, trees and other ground-based objects.
Digital Terrain Model (DTM)	A 3D display of vector data that features natural terrain and regularly spaced points.
Drag	The force that counteracts thrust on an aircraft. Drag increases with speed.
Drone	An unmanned aircraft that can navigate autonomously, without human control or beyond line of sight.
Earth Observation	Looking down at the Earth from aircraft and satellites using various sensors which make images that are afterwards used to study what is happening on or near the Earth's surface. (Related word: remote sensing)
Electromagnetic Spectrum	The range of energy which contains parts or "bands" such as the visible, infrared, ultraviolet, microwave (radar), gamma ray, x-ray, radio, and which travels at the speed of light. Different parts of the electromagnetic spectrum have different wavelengths and frequencies. (Related words: spectrum, radiation, spectral band)
Emit	This word means the same as "sent out" or "given off". The sun emits radiation, some of which we can feel as heat and some of which we can see as light. The radar sensor in RADARSAT emits a radar beam. (Related words: transmit, radiation)
Enhancement	Anything that you do to an image to make it simpler, faster or more accurate to analyze and interpret by eye is a form of "enhancement". Special enhancement techniques can improve color, brightness, contrast, sharpness, etc. (Related words: visual interpretation)

Term	Meaning
Extended Visual Line of Sight (EVLOS)	An operating method in which the drone operator relies on remote observers to continuously keep the drone within visual line of sight.
Federal Aviation Administration (FAA)	A branch of the department of transportation in a United States-based government organization that focuses on aviation regulations. The FAA is responsible for the United States and its surrounding international waters.
Flight crew	Everyone working directly with the drone operation.
Flight Log	A record of a single flight. Traditionally, this would be written by a pilot.
FOV	Field of View: What the drone sees from the camera.
FPV	First Person View This is a method of flying a drone. Most commonly, FPV drones transmit video feed to goggles or a headset, although it can also transmit to a mobile device or another display. Also known as remote-person view (RPV) or video piloting.
GDVI	Green Difference Vegetation Index. See VARI.
Geographic Information System (GIS)	A system that lets users visualize, question, analyze and interpret data to understand spatial relationships, patterns, and trends.
Geotag	An electronic tag (grouping) of geographic information (coordinates) that is assigned to media such as photographs and videos via the process of geotagging..
GeoTIFF	A public domain metadata standard that allows georeferencing information to be embedded within a TIFF image file.
Gimbal	The mount of the camera to the drone. It allows the camera to pivot.
Global Navigation Satellite System (GNSS)	A satellite navigation system with global coverage, such as GPS, GLONASS and the European Union's Galileo system.
Global Positioning System (GPS)	Refers to the United States NAVSTAR Global Positioning System, a space-based navigation system that provides location and time information anywhere on or near the Earth.
Globalnaya Navigazionnaya Sputnikovaya Sistema (GLONASS)	Refers to Russia's version of GPS, another navigation system with global coverage and similar precision.
Gravity	The downward force on an aircraft.
Ground Control Point (GCP)	A location or object on the ground that has precisely known coordinates. Used to improve the precision of DSMs created by photogrammetric analysis of a series of images.
Ground Control Station (GCS)	A ground-based control center, such as a laptop computer, that allows for human control of UAV flights.
Ground Resolution	(see Ground Sampling Distance)
Ground Sampling Distance (GSD)	The distance between two consecutive pixel centers measured on the ground, also referred to as ground resolution. A GSD of 5 cm means one pixel in the image represents 5 linear centimeters on the ground.
Ground Station	See RECEIVING STATION

Term	Meaning
Ground Truthing	Remote sensing analysts must be sure that their image analysis is accurate. This is done by field where they go out to the actual places shown in the images and confirm that what they think they see on the image is actually true. (Related words: verification, calibration)
Headless Mode	A setting that orients your drone to you (as the controller) instead of to the direction that the drone is actually facing. Typically a beginner feature.
Image	The picture that is a result of the sensing process. A remote sensing image can be displayed on a computer monitor or it can be made into a printed copy. (Related word: imagery)
Image Analysis	This is the process of studying an image in order to explain, measure, map, count or monitor what is on the Earth's surface. (Related words: interpretation, classification)
Image Overlap	An intersection of imagery. The more image overlap, the better the output. It helps the software process images and create a clearer, more detailed map.
Index Calculator	A generated index map/grid where the color of each pixel is computed using a formula that combines different bands of the reflectance map.
Index Map	A map that represents specific values for vegetation or soil, such as greenness or soil moisture.
Inertial Measurement Unit: (IMU)	An electronic device used to maneuver aircraft, which detects changes in acceleration and rotation. Comprised of sensors such as accelerometers, gyroscopes and sometimes magnetometers.
Infrared imagery	The output of images based on heat energy of the infrared spectrum.
Keyhole Markup Language (KML)	An XML notation for expressing geographic annotation and visualization within internet-based, two-dimensional maps and three-dimensional Earth browsers.
Keypoint	An identifiable point in an image. The process of photogrammetry involves the matching of common key points on two or more images.
LAANC	The Low Altitude Authorization and Notification Capability.
Landsat	Owned and launched by the United States, this is a series of remote sensing satellites that use the visible and infrared parts of the spectrum to record images of the Earth's surface. (Related words: SPOT, IRS, RADARSAT, NOAA, satellite)
LiDAR	A remote-sensing technology that measures distances by illuminating a target laser and analyzing the reflected light.
Lift	The upward force on an aircraft. Provided by the wings of an airplane and the rotor(s) of a rotorcraft.
Light-emitting Diode (LED)	a semiconductor device that emits light when an electric current is passed through it.
Line-Of-Sight	When two objects (such as a satellite and a receiving station) have nothing in between them, then they are in "line-of-sight" of each other. When a satellite is on the other side of the Earth from a receiving station, the Earth is in between them, so the satellite and the receiving station are not in "line-of sight" of each other. (Related words: visibility, data reception)
LiPo	Lithium Polymer Batteries. This is the most common type of power source for drones.
Magnetometer	a geophysical instrument that measures the strength of the Earth’s magnetic field. Used to alongside sensors such as gyrometers and accelerometers to determine an aircraft’s altitude (it’s orientation relative to the Earth’s horizon).

Term	Meaning
MAV	Micro Air Vehicle, Micro Aerial Vehicle. In the United States, this refers to drones weighing less than 55 lbs. (25 kg).
Meta Data/Metadata	A set of data that describes other data. In the case of a photo, metadata might include where an image was captured (i.e., its geographic coordinate), who captured it, the camera used and more.
Monitoring	Keeping track of how things change over time. For example, with remote sensing, using several images taken over time, you can monitor the result of logging in a forest or how much of an oil slick in the ocean has been cleaned up or how well crops are growing or how much a glacier has melted or how far a plume of sediment travels in a lake, etc. (Related words: change detection, multi-temporal analysis)
Mosaic	A big image made by combining smaller images. .
Multispectral imagery	The output of images that measure wavelengths through light, which then comes together in multiple layers of wavelengths to create geographically accurate mosaics.
Near-IR	The space on the Electromagnetic below visible red.
Normalized Difference Vegetation Index (NDVI)	One of the most commonly used vegetation indices in precision agriculture. NDVI provides information regarding the chlorophyll content in plants. NDVI=(NIR-RED)/(NIR+RED)
NOTAM	Notice to Airmen. This is a warning of potential hazards filed with an aviation authority. Hazards included in NOTAMs can include air shows, closed runways, miliary exercises, passage of flocks of birds (BIRDTAM).
Obstacle Avoidance	This sensor based feature is on most higher end drones.
Orbit	The path traced by a satellite as it passes around a planet. (Related words: path, satellite, near polar, geostationary)
Orthomosaic	A large image comprised of adjoining orthorectified images that have been digitally reconstructed. A common mapping drone output (often in GeoTIFF format).
Orthophoto	An aerial image where the effect of the central projection has been removed (orthorectified) according to the DTM and the orientation of the image. Refers to a single image from a satellite, aircraft or drone.
Parallax	The effect caused by an object's apparent location viewed from two different lines of sight.
Part 107	Regulations from FAA for drone operators. To receive their Part 107 pilot license, they must pass a test that covers FAA regulations and procedures for safe operation.
Payload	This can include cameras, lights, landing gear, proper guards.
Payload	A component or product carried by a drone to fulfil a specific mission. In the case of aerial imaging drones, the payload is the camera.
Photogrammetry	The science of recording, measuring and interpreting photographs through data retrieved about physical objects and the environment.
Pitch	The drones rotation, when the nose rotates up or down in relation to the horizontal plane.

Term	Meaning
Pitch	An aircraft's rotation when the nose moves up or down about a transverse axis. For fixed-wing aircrafts such as the senseFly eBee, this axis runs from wing to wing.
Pixel	The smallest unit in a digital image. A satellite image is made up of a matrix of many pixels, each having its own digital value. (Related words: image, digital analysis)
Platform	This is what carries a sensor - usually a drone, satellite or an airplane. But a remote sensing platform could also be a hot-air balloon, a tall tower, etc.
Point Cloud	A set of data points in a 3D coordinate system. These points are typically defined by X, Y and Z coordinates and additional information such as intensity, RGB value or class.
Post-processing kinematic (PPK)	A kinematic technique that corrects geotag locations after the drone data has been captured and uploaded; an alternative technique to RTK.
Prop	Propeller. The prop on a rotorcraft provides lift and thrust. In an aircraft it provides thrust.
Quadcopter	This name is specific to aircraft with just 4 rotors. Small drones, like DJI Mavic Air 2S, are quadcopters. Larger drones can have 6 or 8 rotors (known as hexacopter or octocopter).
Radar Shadow	Just as with a flashlight, a radar sensor "illuminates" a scene, and if an object blocks the beam, a shadow area develops behind it. Such shadows can be seen in a radar image. Radar shadows are pure black - they contain absolutely no information. (Related word: radar beam)
Radio link	The quality of the wireless connection between the drone and the ground control station. Each radio unit consists of a transceiver and a directive antenna, typically operating at microwave frequencies in the range of 6-23 GHz.
Raster Data	in its simplest form, a raster consists of a matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing information, such as RGB value, altitude or temperature.
Rasters	drone-captured digital photographs.
Real-Time Kinematic (RTK)	A technique used to enhance the precision of position data derived from satellite-based positioning systems, which relies on a single reference station or interpolated virtual station to provide real-time corrections.
Receiving Station	At a receiving station, antennas collect the signals sent by an orbiting satellite. Electronic devices process the signals and the data are stored. Usually the station also converts the data into usable digital and printed images. (Related words: satellite, reception, downlink)
Red Green Blue (RGB)	The visible region of the electromagnetic spectrum, from approximately 400 nm to 700 nm.
Reflectance Map	A display that provides scene radiance as a function of surface orientation.
Reflection	Reflection occurs when radiation (light, radar signals, etc.) bounces off a target. It is very important in remote sensing how that reflection happens, how much is reflected and how the radiation is changed in the process of reflection, because it tells us much about the target that caused the reflection.
Remote Sensing	Remote sensing is the action of collecting images or other forms of data about the surface of the Earth, from measurements made at some distance above the

Term	Meaning
	Earth, processing these data and analyzing them. (Related words: earth observation, environmental monitoring)
Remote Sensing	The process of obtaining information about a physical element or surface from a distance, i.e. via UAV.
Remotely Piloted Aircraft System (RPAS)	Describes a configurable set of remotely piloted aircraft elements.
Resolution	Spatial resolution describes how clearly you can see detail in a picture. Consider the focussing done by a camera. If the picture is blurry and you can't see small objects, the resolution is poor (low resolution). If the picture is sharp and you can see small objects, the resolution is good (high resolution). Resolution is also used in describing color detail (how similar colors are) and even time detail (how close in time things happen). (Related words: detail, image analysis)
Revolutions Per Minute (RPM)	Describes the rotation speed of a motor or other machine.
Roll (airplane)	An aircraft's rotation about a longitudinal axis, running from nose to tail.
Roll (drone)	To move the drone laterally, from side to side.
RPA	Remotely Piloted Aircraft. This is an accurate term but seldom used. Most agencies and pilots prefer RPAS – probably because a longer acronym is less confusing. The RPA acronym is more commonly used in robotics (robotic process automation) which doesn't have anything to do with aerial vehicles.
RTF	Ready to Fly. An RTF drone comes ready to fly from the manufacturer. Most consumer and prosumer drones are RTF.
RTH	Return to Home. This feature will bring your drone back to its preset home point, usually your point of take off. This is an important feature to watch for. And to make sure it's set before take off.
Satellite	A satellite is a natural or man.made object continuously orbiting above the Earth or another planet or star. A remote sensing satellite carries one or more instruments for recording images of the Earth, which are transmitted to a receiving station using radio waves. (Related words: platform, receiving station, orbit)
Scanner	While a camera would take a picture of an area all at once, a scanner is a device that examines an area point by point until the entire area has been imaged. These points become the pixels in a digital remote sensing image.
SD Card	Secure Digital card is a non-volatile memory card used to store data. MicroSD cards are commonly used by drone cameras (and cell phones).
Sensor	A sensor is the device that records a remote sensing image, much like a camera. (Related words: scanner, platform)
Spectrum	See ELECTROMAGNETIC SPECTRUM
sUAS	Small Unmanned Aircraft System. This is a subcategory of UAVs, typically under 55 lbs (25 kg) in weight. The "s" is written in lowercase.
Target	Targets are the features being studied in a remote sensing image. (Related words: backscatter, reflection)
Temporary flight restriction (TFR)	A non-permanent restricted area for air travel determined by the FAA.

Term	Meaning
Thrust	The forward force on an aircraft. Provided by the propeller(s) of an airplane and the rotor(s) of a rotorcraft.
Transmit	Energy that passes through an object or material is "transmitted". This is in contrast to energy that may be reflected or absorbed. A window (which is not too dirty) allows light to transmit through and thus we are able to see through glass. (Related words: reflect, absorb, backscatter)
TRUST	The Recreational UAS Safety Test. All recreational flyers must pass an aeronautical knowledge and safety test and provide proof of test passage (the TRUST completion certificate) to the FAA or law enforcement upon request.
UA	Unmanned Aircraft. This is a blanket term and is seldom used because it is too broad.
UAS	Unmanned Aircraft System. This term has been used by aviation authorities in the USA (FAA) and UK (CAA). The EASA (European Union Aviation Safety Agency) uses the terms UAS and drones interchangeably.
UAV	Unmanned Aerial Vehicle. This has become somewhat of an informal term for UAS. Online, RPAS are often referred to as drones or UAV. But this acronym isn't commonly used by aviation authorities or agencies.
UAVS	Unmanned Aerial Vehicle System. Similar to UAV, this is somewhat of a slang reference to UAS.
Unmanned Aerial Vehicle (UAV)	An aircraft operated with no pilot on board plus its associated elements.
VARI	Visible Atmospherically Resistant Index. VARI= (Green - Red)/ (Green + Red - Blue). Also called Green Difference Vegetation Index (GDVI)
Vector Data	A representation of the world using points (e.g. featuring x, y, z coordinates), lines and polygons. Useful for storing data that has discrete boundaries such as country borders and parcels of land.
Virtual Reference Station (VRS)	Networks that use real-time kinematic (RTK) solutions to provide high-accuracy RTK Global Navigation Satellite Systems.
VLOS	Visual-line-of-sight.
Waypoint	A series of defined coordinates that identify a specific point in space.
Working area	A dedicated area where the base station and the drone's operating space are located.

Drone Modes

The standard flight modes for DJI drones.

A-Mode	Attitude Mode or ATTI Mode. Your drone maintains a set altitude, but not position. You can still navigate horizontally, but not vertically.
P-Mode	This is the standard flight mode. It makes use of all sensors, including GPS and all vision sensors. This not only helps safer flight (obstacle avoidance) but it also makes it more stable hovering and precise flight. Used for most mapping.
S-Mode	Sport Mode. This mode allows your drone to fly faster. Most sensors are turned off, with the exception of GPS.

Software/Hardware

Putting together a complete package can be daunting. For mapping all the parts need to work together. You will need:

- Drone
- Display for the controller
- Software to control the drone

Software will drive the hardware decisions as it must be compatible with not only the drone, but the mobile device used as the display.

DroneLink	https://www.dronelink.com/	Use for mapping. Hobbyist plans are one-time purchase. Elite plan ($99) supports mapping. Check for supported drones.
WebODM	https://webodm.net/	Use for image processing. Free app. Supports local or remote processing. Remote process has a fee. For local processing you will need a computer with at least 16GB of RAM. Note: Install of the local processing "node" is complex. You can purchase an installer to make this easy (recommended, $49).
QGIS	https://qgis.org/	Open source GIS.
DroneDeploy	https://www.dronedeploy.com/	An online subscription service that controls the drone and does image processing. The "ag" package is $1000/year, but some educational discount might be available.

Sample Budgets

The budgets below are an estimate of costs for different configurations. There are many other options. In addition to the initial cost, maintenance cost of 10%/year might be a good estimate of ongoing expenses. At the very least props and batteries will need replacement. Note: This may not cover repairs if you are prone to crashes! All configurations should be confirmed before purchase.

Simple RGB Solution

Item	Cost	Notes
DJI Mavic Air 2 Combo	1000	Case, 3 batteries, spare props, RGB camera
DroneLink	100	One-time Purchase
WebODM	50	One-time purchase

Item	Cost	Notes
Processing Computer (ex. Dell Vostro 5890, 16GB RAM, 256GB hard drive)	1000	
QGIS	-	
IPad Mini	550	(need bracket adapter), cell service is not required.
Old Smart Phone (iPhone or Android), check with manufacturer for supported models.	-	A phone can be used as a controller display. It needs WiFi, but cell service is not required. Needs to run the DJI Fly App and DroneLink.
Micro SD Card (64GB)	15	Suggest having two cards.

RGB Option with DroneDeploy

Item	Cost	Notes
DJI Mavic Air 2 Combo	1000	Case, 3 batteries, spare props, RGB Camera
DroneDeploy	1000	Annual Subscription
QGIS	-	
IPad Mini	550	(need bracket adapter), cell service is not required.
Old Smart Phone (iPhone or Android), check with manufacturer for supported models.	-	A phone can be used as a controller display. It needs WiFi, but cell service is not required. Needs to run the DJI Fly App and DroneDeploy app.
Micro SD Card (64GB)	15	Suggest having two cards.

Near IR Sensor Solution

Item	Cost	Notes
Phantom 4 Pro with Sentera Sensor	4700	Hard Case, 3 batteries
DroneLink	100	One-time Purchase
WebODM	50	One-time purchase
Processing Computer (ex. Dell Vostro 5890, 16GB RAM, 256GB hard drive)	1000	
QGIS	0	
IPad Mini	550	(need bracket adapter), cell service is not required.
Old Smart Phone (iPhone or Android), check with manufacturer for supported models.	-	A phone can be used as a controller display. It needs WiFi, but cell service is not required. Needs to run the DJI Fly App and DroneLink.
Micro SD Card (64GB)	15	Suggest having two cards.