1 Appendix: Image capture from a drone

Version No	Date	Author	Comments/Modifications
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Abstract

Georeferenced crop rows are useful for certain precision agricultural (PA) applications. A flexible and inexpensive way for achieving this georeferenced lines is through image processing and certain computer vision techniques. This appendix presents a protocol for acquiring aerial images using simple (RGB) cameras onboard RPAS platforms over sugarcane fields. This protocol is divided in the following four steps: **1)** Scope and initial technical considerations, **2)** Preflight considerations, **3)** Flight considerations and **4)** Orthomosaic generation.

A1. Introduction

This section describes a image capture protocol which includes recommendations, characteristics and limitations for capturing high resolution aerial images used for crop rows generation in sugar cane fields. A set of valid images are needed for orthomosaic generation in an Agisoft photoscan software. Resulting orthomosaic are needed as an input for the developed *Crop Rows Generator (CRG) - QGIS Plugin.*

A2. System overview

In Figure 1.1 shows a workflow diagram summarizing from flight planning, data acquisition in flight and post-processing captured data to delivery the orthomosaic as an end product ready to be processed for the *Crop Rows Generator (CRG) - QGIS Plugin*.

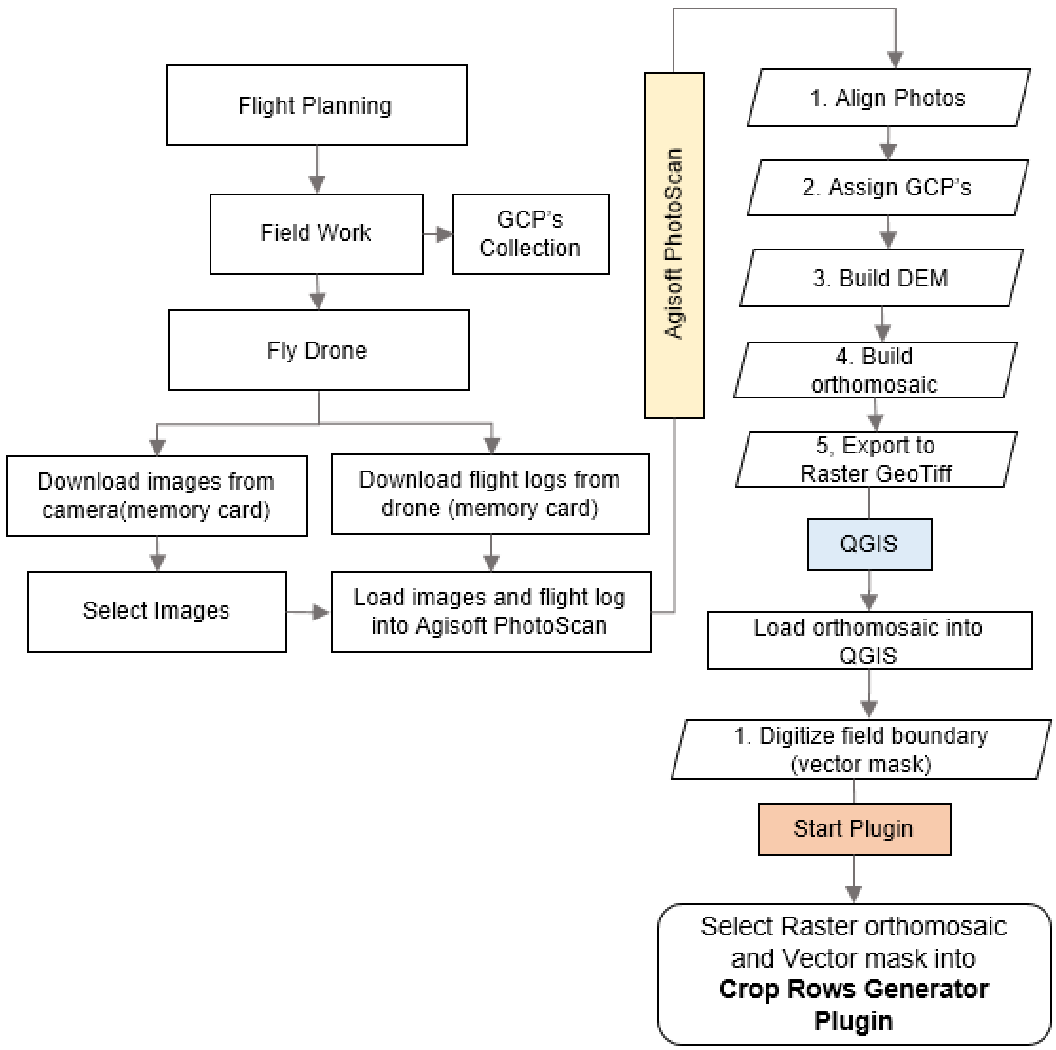

Figure 1.1: Workflow for high resolution raster orthomosaic image generation and vector mask required inputs for crop rows generator QGIS plugin

A3. Orthomosaic Generation Protocol

A3.1. Scope and Initial Technical Considerations

This section is based on technical considerations that must be taken into account in order to have valid inputs that will later be used for crop rows generation process in the framework of the developed QGIS plugin. A list of technical considerations is listed below.

1. **Target Crop :** Sugarcane.
2. **Crop Variety :** Any.
3. **Growing Trait :** Ratoon crop or Plant cane.
4. **Crop Stage :** Early Stages.
5. **Image Sensor :** Any RGB Camera up to 12 Mega pixels.
6. **Image Scene :** Outdoors with normal light conditions.
7. **Imagery Type :** Nadir images
8. **Aerial Platform :** Any fixed-wing or rotary-wing.
9. **Orthomosaic Generation :** Agisoft PhotoScan Software.

A3.1.1 Growing Trait

The following Table 1.1 was constructed based on criteria experts consulted in the requirements analysis and only applies to sugarcane growing crop in *Colombia Cauca Valley* conditions and for the specific application of detection of crop rows.

Table 1.1: Appropriate scheduling for image capture in sugarcane

Growing Trait	**Criteria**	**Min**	**Max**
Plant Cane	Low germination ratio	>60 das	<100 das
Plant Cane	High germination ratio	>50 das	<90 das
Ratoon Crop	Low post harvest residues incidence	>45 dah	<60 dah
Ratoon Crop	High post harvest residues incidence	>60 dah	<75 dah

das: Days after seed, **dah:** Days after harvest

A3.2. Preflight Considerations

A3.2.1 Aerial Platform

Fixed-wing and rotary-wing are the mainly types of RPAS platforms used. In Table 1.2 shows a few principal characteristics around them. Use of any of these aerial platforms are indifferent and does not affect the final result.

Table 1.2: Common RPAS platforms

Configuration	**Takeoff/Landing**	**Hover**
Fixed-wing	conventional	no
Multirotor	vertical	yes
Electric helicopter	vertical	yes
Gas helicopter	vertical	yes
Blimp	vertical	yes

The main criteria for a platform selection is given by the flight time *information not included in the table. Flight time and flight height limit the working area that could be cover by captured images.

A3.2.2 Parameters for flight planning configuration

Image frontal overlaps, side overlaps, and ground sampling distance parameters are listed below in order to get better results.

- **Frontal Overlap :** 80 %
- **Side Overlap :** 75 %
- **Ground Sampling Distance (GSD) :** Less than 3 cm/pix

Image overlaps and flight planning

The RPAS flight needs to cover the whole Area of interest (AOI) in zig-zag pattern, as is shown in the Figure 1.2. Flight path should be slightly larger than the intended data capturing area.

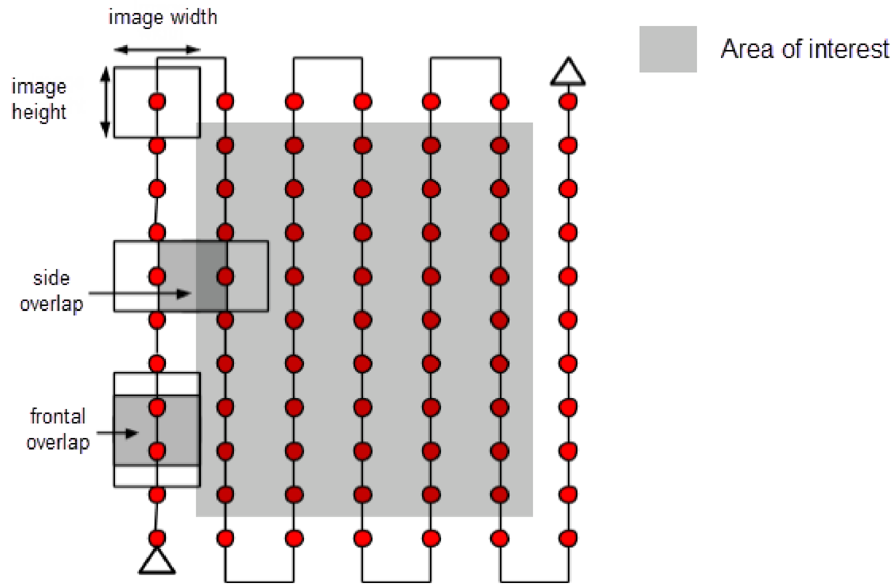

Figure 1.2: Image overlaps and flight acquisition route. (2018, February 02) [Digital Image]. Retrieved from https://support.pix4d.com

Ground Sampling Distance (GSD)

The Ground Sampling Distance (GSD) depends on the parameters of the camera (mainly camera resolution and focal length), the flight altitude and more generally the distance to the ground/target and Terrain surface uniformity as well as the presence of objects, trees or buildings as well.

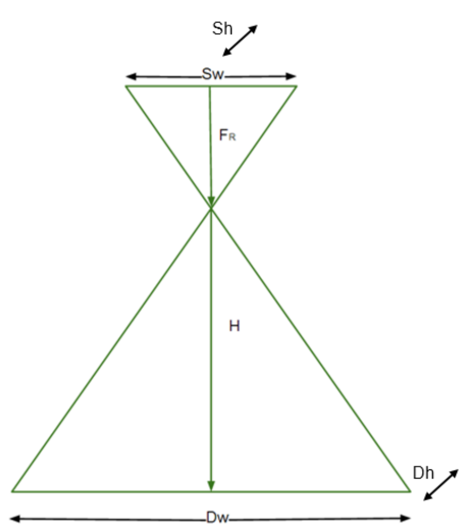

Figure 1.3: Ground Sampling Distance scheme

Sw : Sensor width of the camera (mm)

Sh : Sensor height of the camera (mm)

GSD : Ground Sampling Distance (mm/pixel)

Fr : Focal length of the camera (mm)

H : Flight height (meters)

Dh : Footprint height covered on the ground by one image

Dw : Footprint width covered on the ground by one image

For GSD calculation use this electronic calculator [1]

Table 1.3: GSD example for Canon S110 digital camera

Altitude [m]	**Resolution (GSD) [cm/px]**	**Ground photo width x height[m]**	**Ground photo area [m2]**
50	1.83	73 x 55	4.125
60	2.19	88 x 66	5.808
80	2.92	117 x 88	10.296
100	3.65	146 x 110	16.060
120	4.38	175 x 132	23.100
140	5.12	205 x 153	31.365

Table 1.3 is a GSD example calculation for Canon S110 digital camera with 12 Mpx - Sw:7.6mm, Sh:5.7mm, FR:5.2mm, Iw:4000px, Ih:3000px

A3.3. Field Work

A3.3.1 GCP's Collection

GCPs increase the global accuracy of orthomosaic. Ground control points are large marked targets on the ground, spaced strategically throughout area of interest. First need to determine the GPS coordinates at the center of each. The ground control points and their coordinates are then used to help drone mapping software accurately position the map in relation to the real world around it. The GCPs and their coordinates are then

[1] GSD Calculator https://support.pix4d.com/hc/en-us/articles/202560249-TOOLS-GSD-Calculator#gsc.tab=0

used to help drone mapping software accurately position the map in relation to the real world around it.

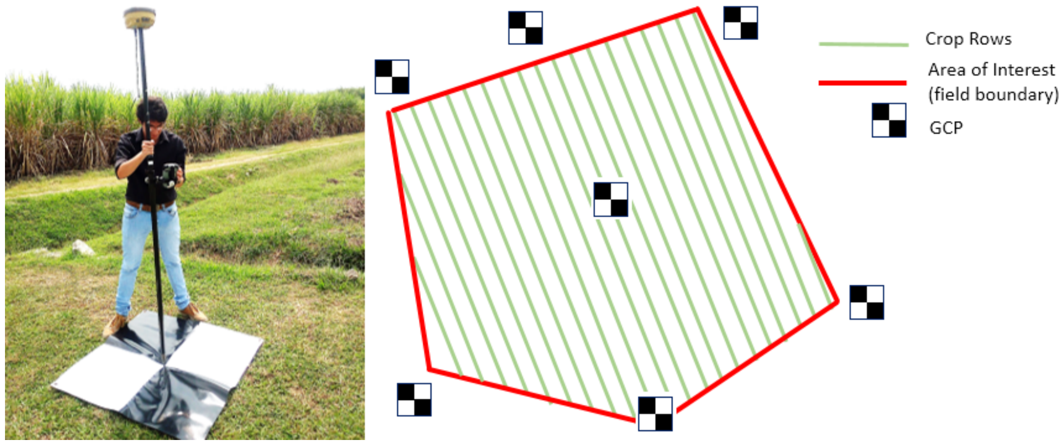

Figure 1.4: Ground control points (GCP) distribution out over the field. GCPs are typically measured with highly-accurate ground-based GPS equipment.

Some recommendations for correct GCP positioning in the field

- GCP must be easily visible in the aerial imagery.
- Use a minimum of 5 large GCPs.
- Evenly distribute GCPs on the ground.
- Make sure the GCPs are unobstructed.
- Measure GCP Center with High Precision GPS/GNSS.

Measuring the Location of GCPs

Measure the GPS coordinates at the center of each ground control point. To do this, you need either a Real Time Kinematic (RTK) or Post Processing Kinematic (PPK) GPS receiver.

A3.4. Field Work

A3.4.1 Flight Conditions

The best weather for RPAs flying is when it is sunny, a reasonable temperature (25 degrees Celcius, for example), and little to no wind.

Table 1.4: General conditions in field

Wind	**Precipitation**	**Cloud Cover**	**Visible Sats**	**K Index**	**TDF**
0 - 24 km/h	No Precipitation	(0/8) or (1-2/8)	>10	<4	10 AM - 1 PM

Cloud cover : Describes the extent of cover by clouds in the portion of the sky visible from the observation point. It is estimated by the weather observer and given in eights by the synoptic service. The following classification is usually made.

Table 1.5: Cloud coverage amount

Cloud amount	**Description**
0/8	clear skies
1-2/8	fair
3/8	lightly clouded
4-6/8	cloudy
7/8	very cloudy
8/8	overcast

K-index : quantifies disturbances in the horizontal component of earth's magnetic field with an integer in the range **0–9** with **1** being calm and **5** or more indicating a geomagnetic storm. These disturbances are caused by solar flares so increased solar activity is likely to have a knock-on effect on your ability to fly in GPS mode. For Planetary K-Index check [2]

Time of Day to Fly (TDF) : the best hours for drone imagery collection are where there are less shadows over the terrain, in a tropical country such as Colombia is between 10 AM to 1 PM.

A3.5 Orthomosaic image generation

Images will be stitched into a single orthomosaic Raster image using **Agisoft PhotoScan**[3] software." Agisoft PhotoScan is a stand-alone software product that performs

[2]NOAA planetary K-Index https://www.swpc.noaa.gov/products/planetary-k-index
[3]Avaliable at: http://www.agisoft.com/

photogrammetric processing of digital images and generates 3D spatial data ". Agisoft PhotoScan turns those simple images into three dimensional geographic data that can be used in combination with other geographic datasets. The workflow from images to products is very often just and easy-to-use black box processing standards. Orthomosaic must be exported to a **RGB GeoTIFF** format. GeoTIFFs are TIFF files that contain spatial reference information.

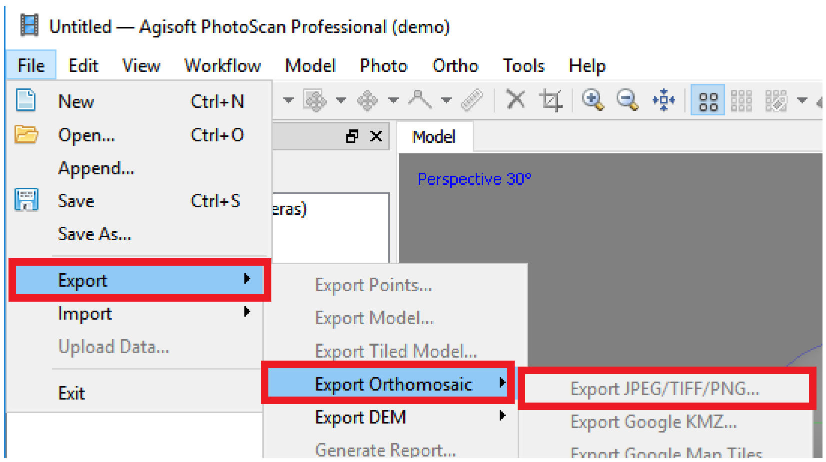

Figure 1.5: Agisoft PhotoScan Export Orthomosaic option

The easiest way is to export it as a geotiff is: File – > Export Orthomosaic – > Export Orthophoto – > Export JPEG/TIFF/PNG (Figure. 1.5). Just make sure that you add ".tif" to the end of your filename. The geotiff format can be read directly by most GIS packages even QGIS. A valid coordinate system needs to be projected (such as UTM - where positions are measured in meters). Required projection can be referenced by the code EPSG:32618 (WGS 84 / UTM zone 18N) or EPSG:3115 (MAGNA-SIRGAS / Colombia West zone) for the Valle del Cauca Colombia West Zone.