An automatic georeferenced crop rows generator using aerial high-resolution images for precision agriculture in sugarcane crops

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Multimedia y Visión por Computador

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Abstract

Georeferenced crop rows are used as an input for guiding precision agricultural machinery. Agricultural machinery is supported by highly accurate, real-time kinematic global satellite navigation systems. Georeferenced crop rows generation is an expensive and time-consuming task. In this article, a crop rows generation in sugarcane crops will be addressed through GIS, image processing and computer vision techniques through a developed QGIS Plugin "Crop Rows Generator (CRG)". CRG involves computer vision techniques and a high-performance computing approach which are capable of process high-resolution large images obtained by a Drone and on these images detect, generate and mapping crop rows in sugarcane fields, with a few clicks. The accuracy in generating Crop Rows lines with CRG are in range between +-(2.5 to 10) cm of horizontal error.

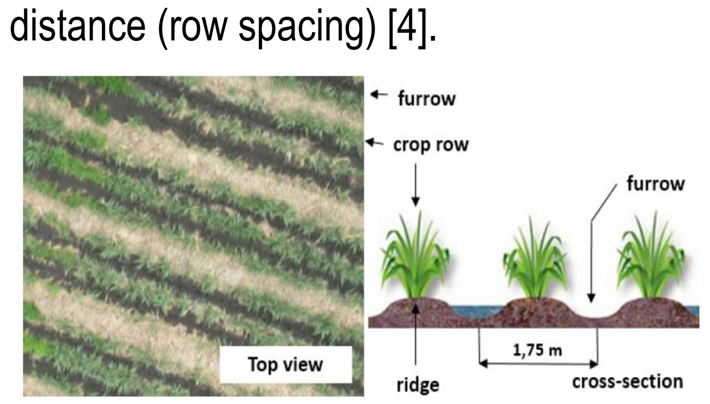
Keywords: Computer Vision, Crop Rows, GIS, HPC, Precision Agriculture, QGIS.

Introduction

The availability of georeferenced spatial data has opened new opportunities for crop management in modern agriculture [1]. PA applies a combination of technologies such as global positioning systems (GPS), real-time kinematic global navigation satellite systems (RTK-GNSS), remote sensing (RS), electronic sensors and devices, geographic information systems (GIS), and computer vision (CV) in order to provide the necessary information to make the local management of the agricultural activities at within field detail feasible. An accuracy of centimeter level is needed to achieve the required operation objectives. From the application domain, sugarcane is an essential crop for the Colombian Cauca River Valley economy. In 2018 there are more than 240.000 hectares growing in five administrative departments (Caldas, Risaralda, Quindío, Valle del Cauca, and Cauca) [2].

Sugarcane Crop Rows

Furrows are small and parallel channels, made to conduct water in order to irrigate and drain the crop. A crop is usually grown on the ridges between the furrows [3]. Crop rows direction is determined by the field design that, at the same time, it depends on the topography of a site. In the Colombian sugar industry of the valley geographical area of the Cauca river, the most common row spacing distance is 1.75 m and length between 130 to 150 m, due to mechanization and irrigation practices. In some cases, the distance between the wheels of the tractor is used to define planting distance (row spacing) [4].

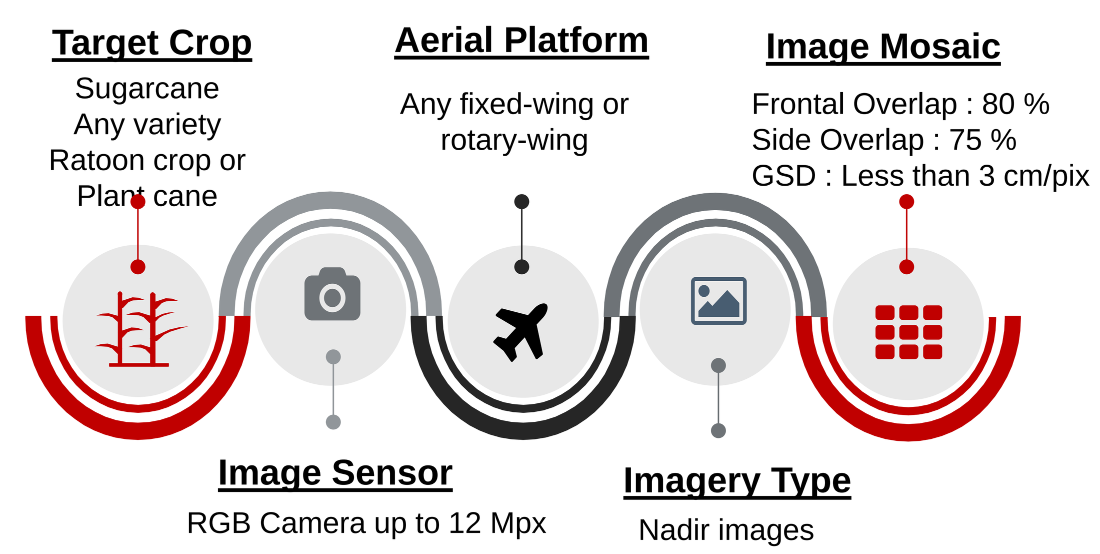


An aerial view and cross-section of furrows and ridges in a sugarcane crop.

In the most common precision agricultural operations such as mechanized planting, fertilization, weed identification, calculation of reseeding percentages, harvesting operations (especially at night) at sugarcane fields, georeferenced crop rows are important for guiding machinery within the field.

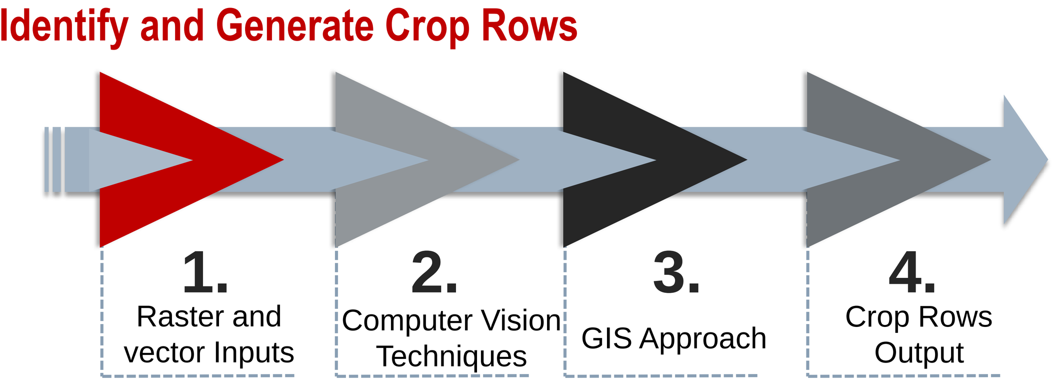
Methodology

In order to acquire valid aerial images using (RGB) cameras on-board drone platforms over sugarcane fields. Image acquisition protocol is divided into the following steps:



Drone flight needs to cover the whole area of interest (AOI). Images will be stitched into a single orthomosaic Raster image using Agisoft Photo-Scan software and results must be exported to an RGB GeoTIFF.

Identify and Generate Crop Rows

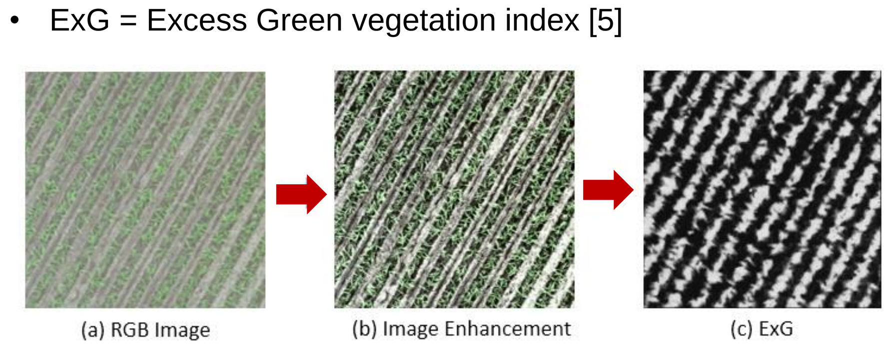


Crop field boundary and raster orthomosaic as an input..

Computer Vision Techniques

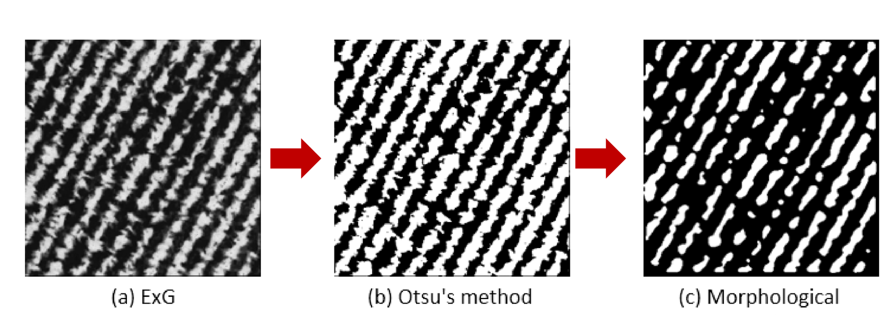
- Orthomosaic is divided into a set of adjacent tiles of the same size
- Contrast enhancement
- Intensity manipulation
- Sharpening and filtering
- ExG = Excess Green vegetation index [5]

Image enhancement



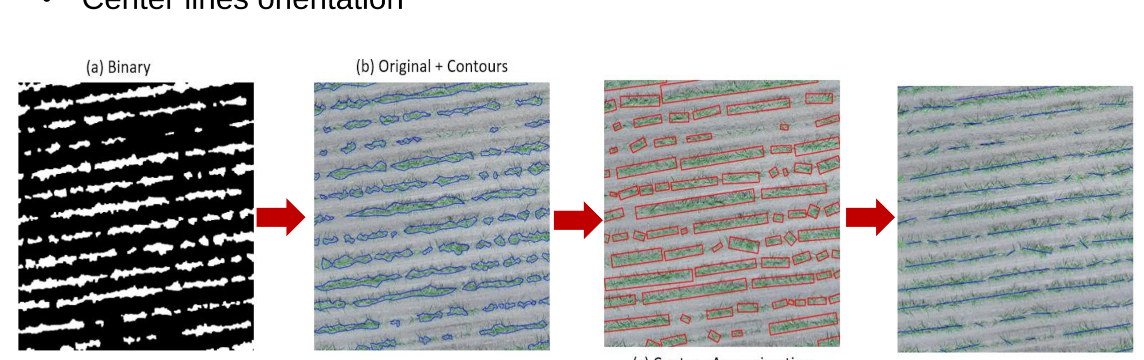
Tile segmentation

- Gray level image to a binary image [6]
- Remove imperfections of a binary image



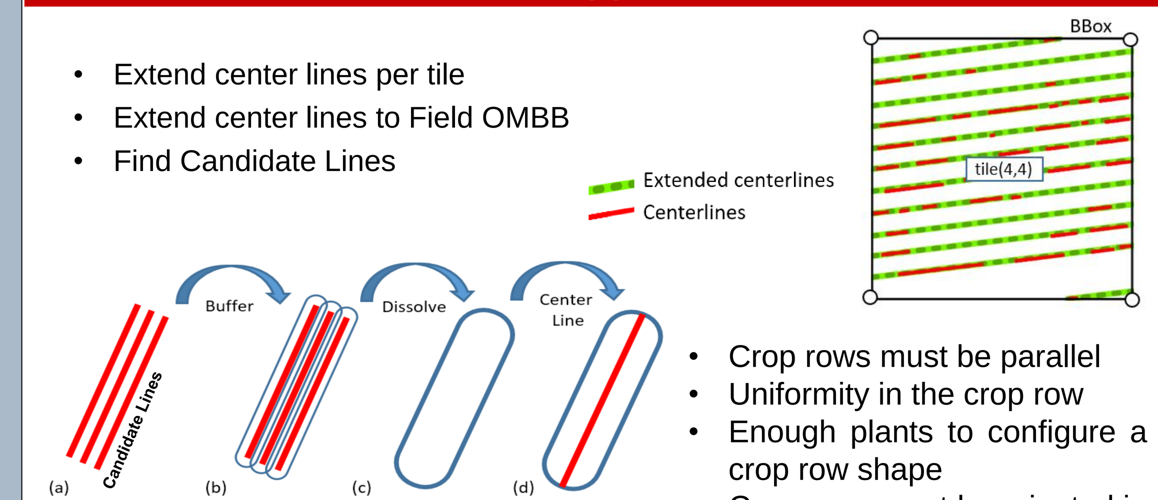
- Contour approximation
- Find center lines
- Center lines orientation

Build Contours & Centerlines



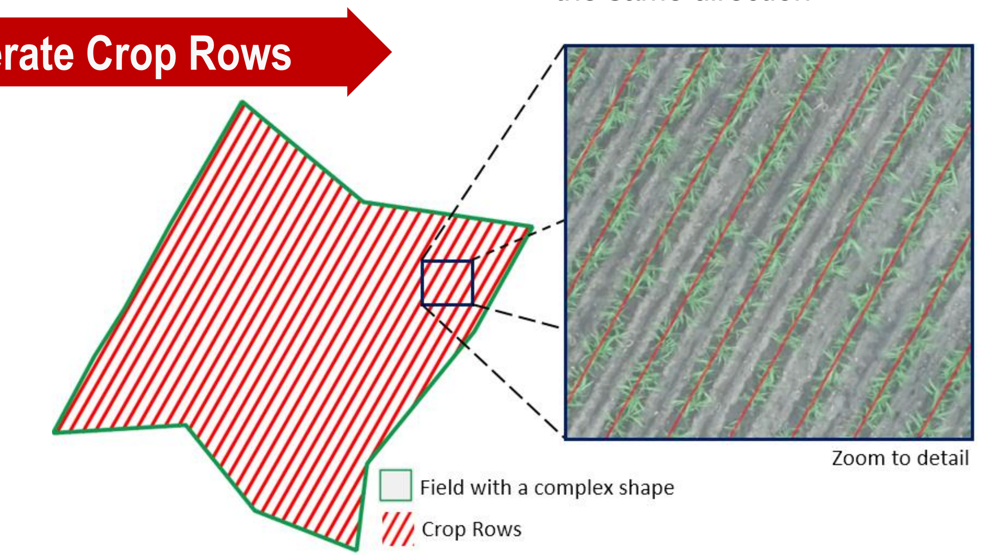
GIS Approach

- Extend center lines per tile
- Extend center lines to Field OMBB
- Find Candidate Lines



- Crop rows must be parallel
- Uniformity in the crop row
- Enough plants to configure a crop row shape
- Crop rows must be oriented in the same direction

Generate Crop Rows

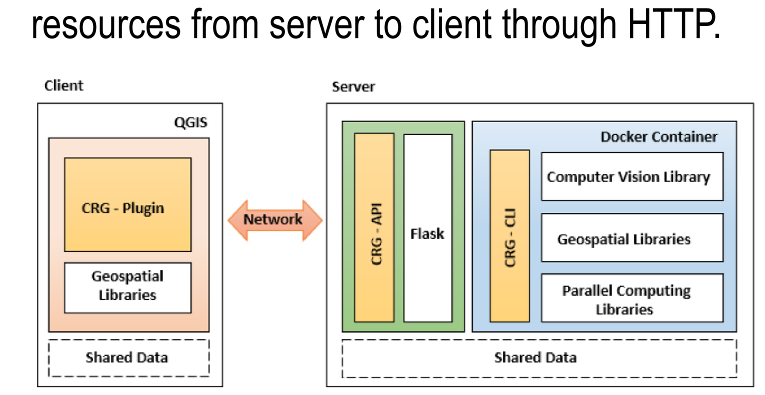


Open Source Application

Server Side: ***CRG – CLI:*** runs inside a docker container that contains everything needed to run: computer vision tasks, geoprocessing tasks and so on.

Client Side: ***CRG - QGIS Plugin:*** runs inside the Quantum GIS environment as a Plugin with access to Geospatial libraries be able to perform geoprocessing task.

CRG - API: provides an interface API for communicating exposed resources from server to client through HTTP.



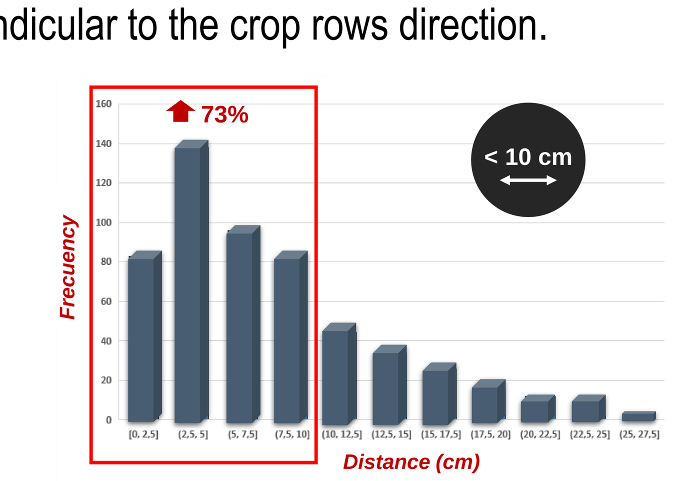
Block diagram for Crop Rows Generator (CRG)

Technology stack used by CRG

Precision Evaluation

A metric of the precision of the developed system can be calculated by a measure of the horizontal error of the crop rows lines generated by CRG against ground truth crop rows. In order to obtain the horizontal errors, line distances between (georeferenced crop rows generated by CRG) and ground truth crop rows (generated by an expert user) were calculated along five transects. Horizontal errors are given in centimeters. Transects are perpendicular to the crop rows direction.

Horizontal errors histogram results of the precision evaluation



Conclusions

Breaking the image down into square chunks and process each resulting chunk in a parallel way as a high-performance computing strategy for handle large and high-resolution aerial images. A hybrid methodology was proposed to identify and generate georeferenced crop rows and it involves computer vision techniques and spatial data geoprocessing. An open source software application (Crop Rows Generator CRG) was developed for crops rows generation. CRG consists of three components. a) As a user interfaces for data input a plugin (Crop Rows QGIS-Plugin) for QGIS software was developed. b) A server-side module for hard processing (Crop Rows - CLI) was developed. c) A communication interface between user and server over an HTTP REST API (Crop Rows - API) was developed. The time for generating georeferenced crop rows using CRG is significantly lower than those achieved conducting similar tasks under field conditions or manual digitizing processes. Tile segmentation by Otsu's thresholding method was adopted to binarize the index tonal images obtained from excess green vegetation index ExG and it allowed separate green pixels (sugarcane plants and weds) from the rest (soil, residues) efficiently. The CRG can be modified and adapted to the needs of other crops such as maize, wheat, pineapple, among others, even, crops arranged in not linear patterns.

Resources

Crop Rows Generator Resources
http://54.186.237.120/croprowsgenerator/

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