ECO-FRIENDLY LIDAR DRONE SURVEYING FOR SUGARCANE LAND LEVELING IN THE CAUCA RIVER VALLEY, COLOMBIA

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Abstract.

Land leveling is a crucial process in sugarcane cultivation in the Cauca River Valley. It plays a vital role in ensuring proper water flow within the fields, reducing fuel consumption for water pumping, promoting seed emergence, and facilitating other mechanized tasks that can be carried out more quickly and efficiently. Traditionally, land leveling involves the use of high-powered tractors (typically around 310 horsepower) equipped with high-precision topographic survey systems from reputable brands like John Deere, Trimble, and Topcom. The topographic survey using RTK signal is conducted using the same tractor that will later be attached to a scraper for leveling. This process takes about 30 minutes per hectare, with a fuel consumption rate ranging from 6 to 9 gallons per hectare. A recent proposal involved evaluating the use of LiDAR technology with the DJI Matrice 300 RTK drone for topographical surveys. This approach is currently operational in one mill and under evaluation in two additional mills in Colombia. The drone-based surveying method has significantly increased efficiency, reducing the time required to just 3 minutes per hectare. Moreover, it eliminates the need for fossil fuels, providing operational, economic, and environmental benefits. To facilitate the processing of LiDAR data, a graphical interface was developed. This interface allows for the conversion of point cloud data from the LAS format to TXT format, which is compatible with Trimble's WM Form batch design software. Trimble's WM-Form® software is widely used for RTK precision land leveling. Additionally, a Python tool was created to transform LiDAR point cloud data into TXT files suitable for use with Trimble's WM Form software. This tool utilizes libraries such as "WhiteboxTools" and "Geopandas" in Google Colaboratory. Notably, this tool simplifies the process by eliminating the need for manual input of coordinate points and instead extracts this information directly from the point cloud, reducing the likelihood of errors and streamlining the workflow.

Keywords.
LiDAR, Land-Leveling, sugarcane, google Colaboratory, WM-Form

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Introduction

Unmanned aerial vehicles (UAVs) can carry a variety of sensors to capture high-quality crop data; imaging systems with different spectral ranges, including red-green-blue (RGB) cameras and multispectral cameras have been used in crops to detect and collect plant morphological data such as canopy cover, vegetation indices, leaf area index, leaf color, and infer information about crop growth; However, these sensors rely on solar energy (passive sensors) to take in information and exhibit imitations inherent to their nature; For example, it only provides planimetric information and the images are sensitive to environmental factors. (Guisado-Pintado et al., 2019; Lin et al., 2019; Mancini et al., 2013), or that the spectral indices that are calculated from the bands of these sensors are saturated with a high amount of biomass. Thus, the images obtained from passive sensors transported by UAVs and spectral indices are not sufficient and accurate to measure crop growth.

On the other hand, the experiments and measurements that are carried out both in Cenicaña and in the Sugar Mills require many personnel to take data on crop growth, measurements of plant height, development indices and percentage of overturning, among others, they are expensive measurements, limited in terms of coverage and deficient in terms of spatial and temporal distribution. that occasionally require destructive sampling; Thus, there is a need to develop non-invasive techniques to obtain data on crop growth, which will make data collection more economical in the medium and long term, more accurate in terms of spatial and temporal representativeness, as well as in terms of quality of data.

LiDAR is a laser object detection and measurement system; it is a technology that does not require sunlight for its operation (active sensor), directly provides 3D coordinates of what is being censused; so that it becomes a valuable alternative for estimating plant height and information about crop growth. Sofonia et al., (2019) indicate that LiDAR outperforms image-based techniques in terms of the ability to capture soil points and the estimation of the physical parameters of biomass. The use of LiDAR is relatively new in agricultural applications. Su et al. (2019) used terrestrial LiDAR to collect morphological data of maize plants, including height, leaf area index, plant area density, and leaf area of each plant. Zhou et al., (2020) used multitemporal LiDAR point clouds acquired by a UAV-based system to monitor changes in the height of corn plants. Canopy height was obtained using commercial software, first generating a Digital Terrain Model (DTM) and a Digital Surface Model (DSM) and then subtracting the DTM from the DSM. Previous research also verified that LiDAR-based measurements, including plant height, projected canopy area, plant volume/area, and panicle dimension, are highly correlated with actual data taken in the field (Sun et al., 2018; Malambo et al., 2019; Su et al., 2019).

The objective of this work was to develop a methodology for data collection with LiDAR for land leveling.

Methodology

LiDAR data processing and spatial analysis are critical components in various fields, ranging from mapping and surveying to natural resource management and geomorphology. The tool developed in Python plays an essential role in carrying out a series of LiDAR data processing and analysis operations from the Zenmuse L1 camera, which is located on board the Matrice 300 RTK drone.

Development

The development was done in the Google Colaboratory environment. The necessary libraries were installed for the code to work optimally. Each of these libraries provides specific functionalities, such as LiDAR data processing, visualization, and spatial analysis. The libraries included were:

- WhiteboxTools: WhiteboxTools is an open-source library that offers a wide range of tools for geospatial data processing and analysis, especially geared towards LiDAR data processing. It provides capabilities for filtering, classifying, and analyzing geospatial data, as well as for manipulating raster and vector data.
- Geopandas: Geopandas simplifies the management of geospatial data in Python, merging the functionality of Pandas (a library for the manipulation of tabular data) with geospatial capabilities. This allows you to work with GeoDataFrames and perform spatial operations.

A significant portion of the code is dedicated to LiDAR data processing, a remote sensing technology used to collect highly detailed geospatial data. Key operations include:

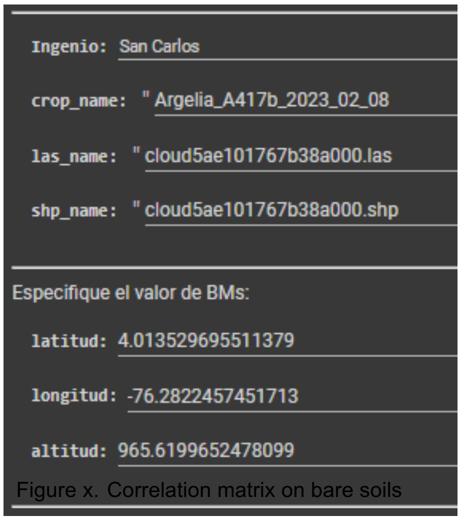
LiDAR Point Density Reduction: This technique preserves a subset of points, which helps reduce the size of the data file and speed up subsequent operations. In this case, they are reduced to 20 stitches per 50 cm².

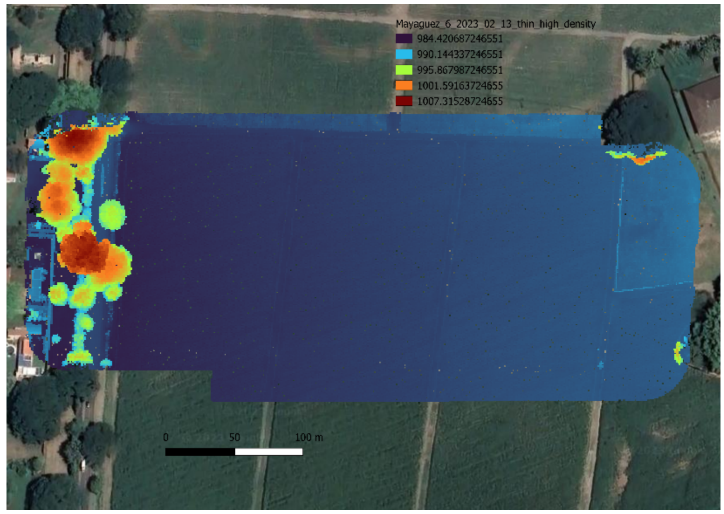
- Elimination of Outliers: Points that may be errors or extremely unusual data are identified and classified, eliminating those that are more than 5 cm apart from other points.
- Ground Point Filtering: Ground points are identified and classified in LiDAR data. This classification is essential to distinguish between points of land and points of objects such as trees or buildings.
- Conversion of LiDAR Data to ASCII Format: Converting LiDAR data to ASCII format facilitates the manipulation and analysis of data.
- Extraction of Specific Class Points: In this case, the Class 2 points are extracted. Classifying points by class is common in LiDAR data and allows for the identification of specific features in the landscape. Classification 2 represents points that the algorithm has identified as terrain.
- Point Conversion to GeoDataFrame: Filtered points are converted into a GeoDataFrame, a geospatial data structure that allows advanced spatial operations to be performed on the data.
- Saving Points in Shapefile Format: Filtered points are saved in a shapefile, a common geospatial format that makes it easy to generate the raster with terrain points and subsequent analysis.

Once these processes have been completed, the data from the calibration point, the perimeter points ordered by a two-parameter tangent arc function, and the points from the Digital Terrain Model are merged. The combined data is stored in a CSV file and converted into a text file compatible with land leveling software, such as WM-Form. This makes it possible to use the processed data in land leveling applications for agriculture and other related industries, facilitating the operation of agricultural machinery and land management efficiently and accurately.

Results

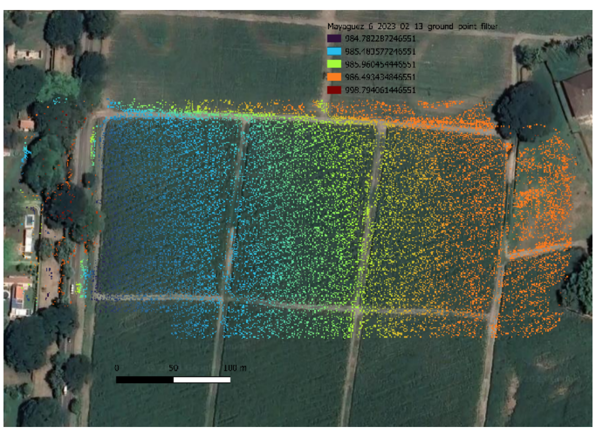
A graphical interface was developed to process the point cloud in LAS format and convert them to TXT format for the WM Form batch design software from the manufacturer Trimble, one of the most widely used systems for RTK precision leveling. (Figure x.)

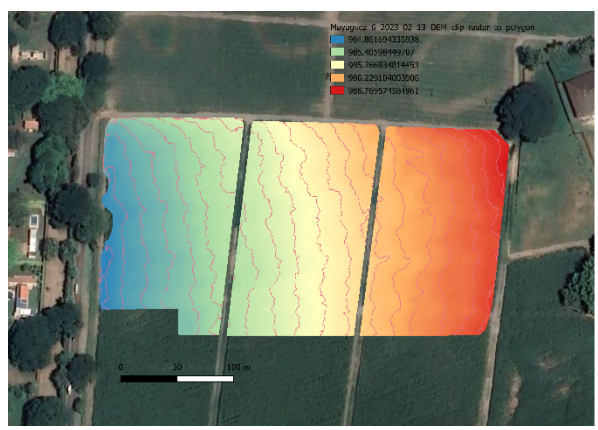




A. Graphical interface.

B. Raster with LiDAR point cloud.





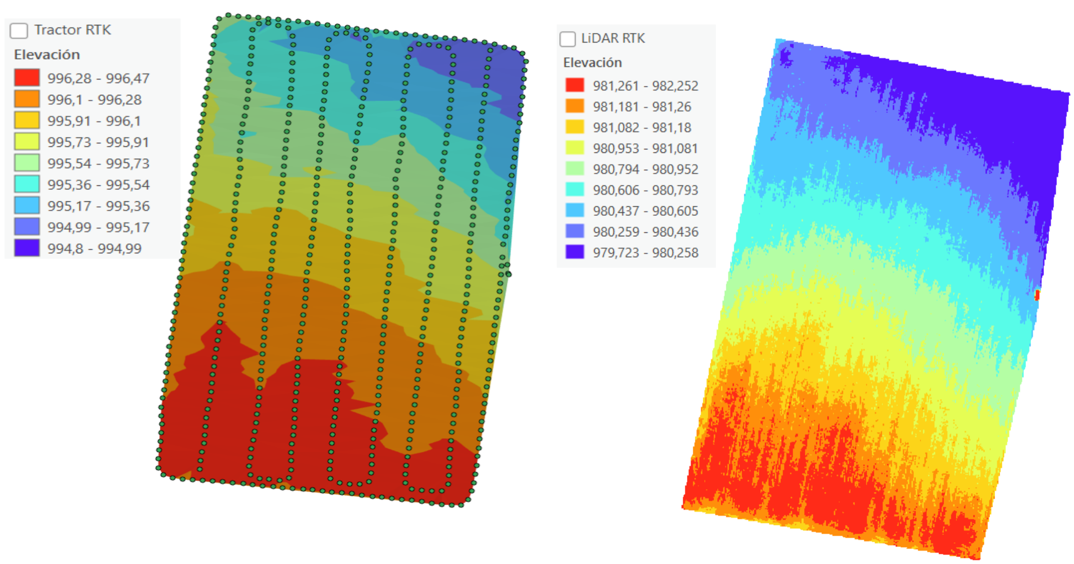
C. Filtered point cloud.

D. Contour lines.

Figura x. Desarrollo de la Interfaz Gráfica para procesamiento de datos LiDAR

The workflow in the field with the use of the developed tool starts with the topographic survey with RTK precision, in the traditional method the same tractor is used that does the land leveling obtaining a point every 20 square meters, the alternative is to use the LiDAR sensor on board a drone, then the point cloud is processed with the developed tool, then it is processed in the cutting design software, in this case WMFORM from TRIMBLE, then the design made is sent to the leveling system to execute the work and finally it can be followed up once the work is finished. Figure 1.

Figure 1. Field Work Flow in a Land Leveling in Sugarcane Cultivation in Cauca River Valley, Colombia



A. Levantamiento con Tractor (Tradicional) B. Levantamiento con Drone y sensor LiDAR

Figura 2. Tipos de levantamientos topográficos con precisión RTK

In Figure 2, you can see the comparison of the traditional survey with the topographic survey with drone and Lidar sensor.

Impact of the work

1. Reduction of fossil fuel use in topographic survey work with Tractor. Depending on the tractor from 4 to 9 gallons/ha.
2. Increased operational efficiency in RTK accurate surveying. LiDAR 120 ha/day approx.
3. Using Survey Products for Bulldozer Leveling in contrast to traditional surveying

Conclusions

LiDAR technology offers an economical, efficient and sustainable alternative for the topographic survey of lots.

The use of this tool made it possible to process the topographic survey quickly and accurately in the leveling of sugarcane lots

The leveling of land in the cultivation of sugarcane decreases the cost and increases the efficiency of irrigation, it is a key operation for the germination of the seed, as it ensures a uniform sowing depth, facilitates agricultural work and guarantees the flow of water in the field, allowing excess water to be evacuated.

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