

Programming and optimization of a drone's flight oriented to precision agriculture

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Abstract—Precision agriculture's main objective is to improve the efficiency of agricultural fields by using different technologies of data acquisition, transmission and processing, combined with multiple automated tools and systems. Two of these technologies are drones, thanks to its ability to overfly field while carrying sensors, and hyperspectral imagery, since the infrared information that it captures is useful to study the status of the cultivations. In this work, a solution to program and optimize the flight of a drone is presented, overflying a specified area while capturing images of it. This optimization ensures the quality of the images, and is programmed in a way that it can be used in future projects with another drone that will carry a hyperspectral camera.

Keywords - Precision adriculture, drone, aerial imagery, hyperspectral technology, flight optimization.

I. INTRODUCTION

In 2016, the European Union approved the “European Initiative to Enable Validation for Highly Automated Safe and Secure Systems” (ENABLE-S3), an investigation project for developing highly automated and autonomous systems. The main contribution from the Institute of applied microelectronics (IUMA) to this project is the implementation of hyperspectral technology [1], which is based in the acquisition of different wavelengths from the electromagnetic spectrum for a same image.

The IUMA has been developing this technology for many years, working in different projects like the European project HELICoiD, focused on brain tumors localization [2] or the European Spatial Agency-financed HyLoC project, developing an hyperspectral images compressor for satellites [3].

Precision agriculture is one scope of the ENABLE-S3 where the IUMA is implied. The goal of this project is to achieve the integration of hyperspectral technologies in agriculture [4][5] by using drones, specifically a Matrice 600 from Dji.

This work is the first phase of this project, focused on the optimization of the flight over a specified area, as shown at Figure 1. To do this, an iOS application is developed using the Software Development Kit (SDK) of Dji, with Objective-C as main programming language. The drone used during this first phase was Dji's Phantom 4, since it is easier to use than Matrice 600, and the SDK is the same for both drones, which means that the code developed can be easily exported to work

with Matrice 600. The images have to be captured by Phantom's 4 RGB camera in a way that allows them to be stitched together.

The iOS application has been developed by modifying an example application from called “GSDemo”, adding the different classes and features needed for this work.

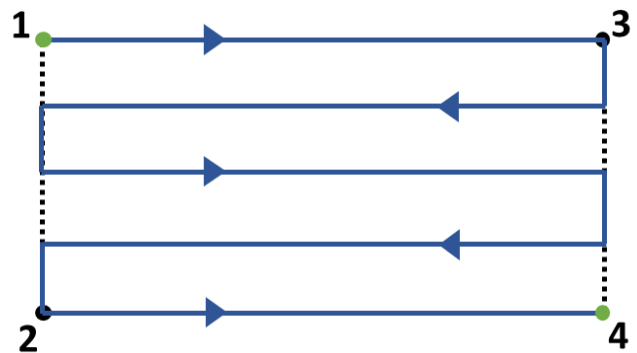


Figure 1. Example of the path followed to cover the area

II. OPTIMIZATION OF THE FLIGHT

There are two factors that have to be taken into account to optimize the flight: image spatial resolution, given by image size (3000x4000 pixels), height and camera field of view (FOV, 94°), and flight time left, limited by the battery level. The result of optimization looks for the minimum flight altitude possible in order to improve image resolution, all this while respecting the flight time limits and the overlap between images. This overlap is required to stitch all the images, since otherwise any image stitching software would be able to find coincidences between them.

The application developed allows the user to select a quadrilateral (the best results are obtained with squares and rectangles) area to analyze by adding its four vertex, and to configure the parameters needed to perform the optimization, which are the range of altitudes to look for the solution, the image overlap and a maximum speed. Time limit is automatically calculated from battery left, but can also be modified.

With the coordinates of the area and all these parameters, the application applies the optimization loop from Figure 2, designed specifically for this project. Starting from the

minimum altitude, trigonometry is applied to determine the spatial resolution of the images.

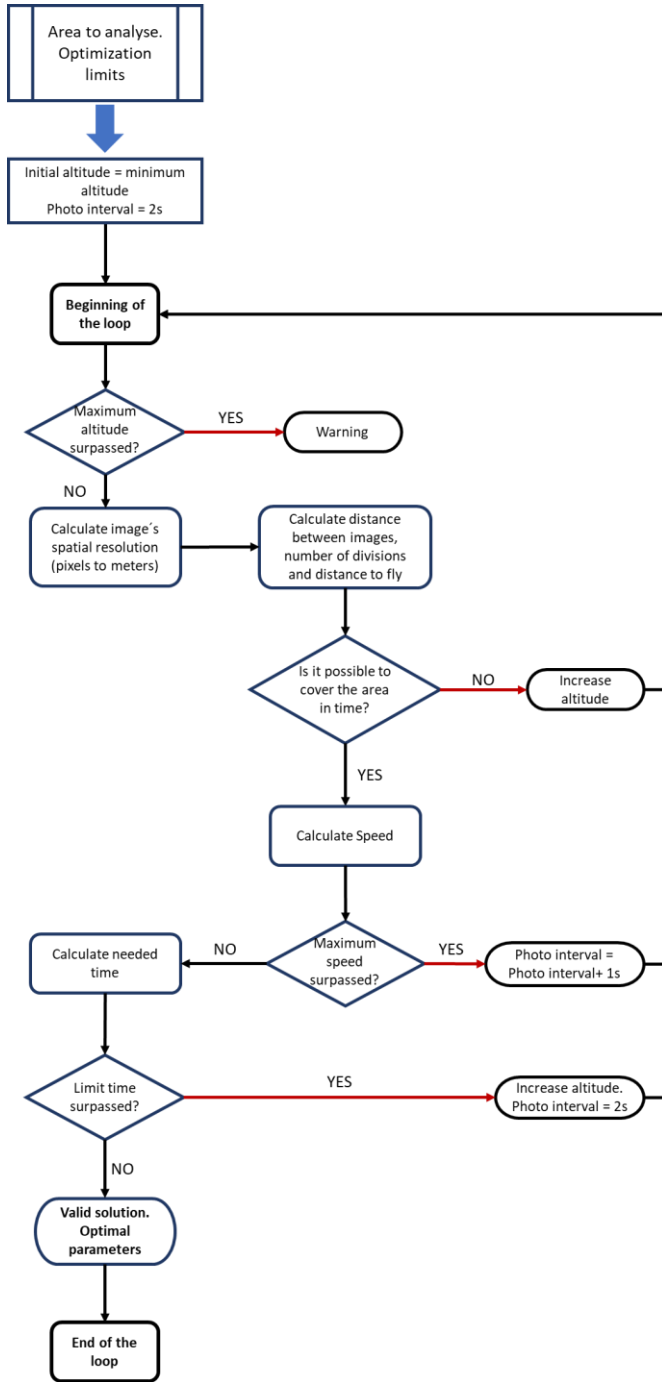


Figure 2. Optimization loop

With this information, the distance between images and required path to cover the area can easily be determined. The time required to complete the flight at 90% of maximum speed is calculated, having a potential solution in case of been smaller than the limit time; otherwise, the altitude would be increased.

From the distance between images and the photo interval, the speed needed is obtained and used to calculate again the

required time. If this speed is bigger than the limit, it will be recalculated changing the photo interval (which can only have integer values), and if the exceeded value were the time, altitude would be increased and photo interval would be reset to 2 seconds, the minimum value.

If all the conditions are fulfilled, the solution is valid and the current altitude, photo interval, calculated speed and the number of divisions are taken as the result, since application is prepared to configure the flight from these parameters, and the drone will be ready to start the flight.

III. RESULTS AND VERIFICATION

A. Optimization loop

The performance of the optimization loop has been tested by defining an area of 401.6x456.7 meters in the application and executing the loop with different battery levels, but keeping the same configuration (maximum altitude = 120 m, minimum altitude = 20m, overlap = 0.5 and maximum speed).

This test has been executed with two different values for the altitude increase, 1 and 5 meters, in order to analyze the differences in the results. Figure 3 contains the comparison between the results from both tests. As expected, flight altitude increases as battery level falls down, due to the need of increasing altitude to reduce path distance and respect time limits. The differences between altitude increases shows that the lower increase means better results, since lower altitude means better resolution.

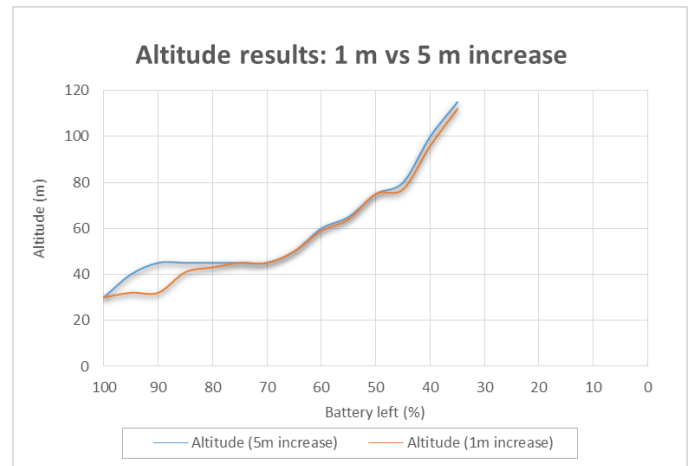


Figure 3. Results with 1m and 5m increase

Figure 4 shows the values of altitude and speed obtained in the case of an increase of 1 m. The oscillation observed in speed values can be explained with the parameters used to calculate it (1), since distance between photos has a set value that can not be modified, in order to ensure image overlap, and photo interval can only have integer values, which makes impossible to keep always a regular value.

$$Speed = Distance\ between\ photos / photo\ interval \quad (1)$$

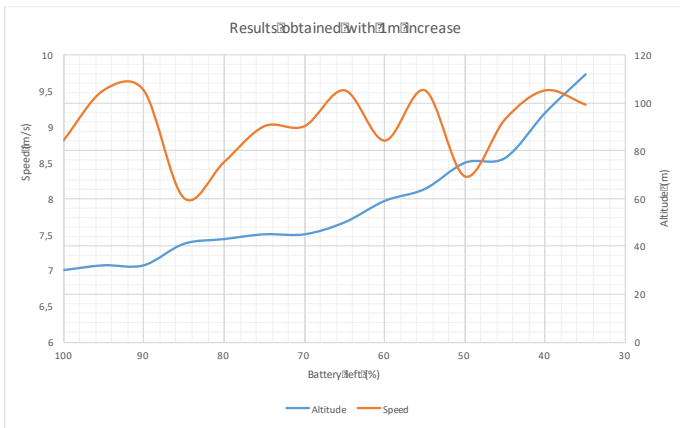


Figure 4. Results with 1m and 5m increase

B. Image acquisition quality

In order to prove the quality of the image acquisition and its performance, this application has been used to overfly the university's football field (Figure 5), stitching the images captured with an open software called OpenDroneMap. Minimum altitude was set to 50 meters to reduce the number of images taken, since this software requires considerable computation time, and overlap was set to 70%.

Captured images keep an appropriate overlap during all the flight, which verifies the functionality of the developed application and the optimization applied.

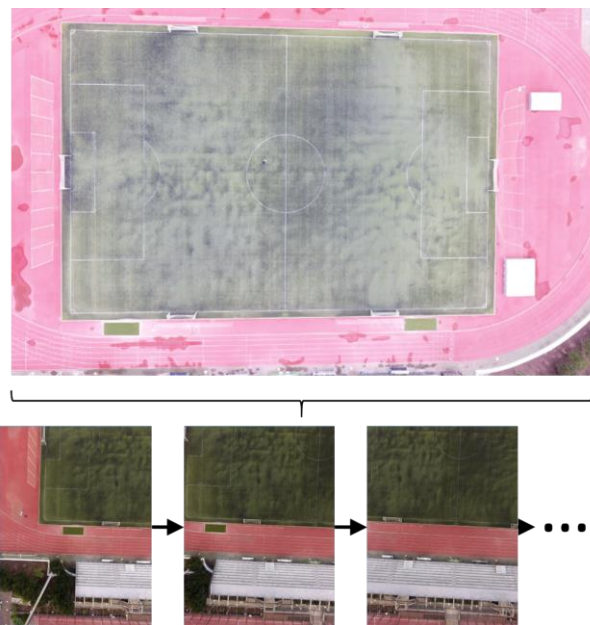


Figure 5. Football field and images captured

Part of these images have been stitched together, and the final image has been overlapped in Google Earth to observe the differences. As seen in Figure 6, the sides of the field do not

coincide, but this is explained with the fact that imperfections appear at the sides of a stitched image. However, the central line of the field does coincide both in the stitched image and Google Earth. This fact proves that images captured using the optimization loop developed are good enough to be stitched with satisfying results.



Figure 6. Stitched image inserted in Google Earth

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