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Very high resolution aerial data to support multi-temporal precision agriculture information management

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Abstract

The usage of small-sized unmanned aerial systems (UAS) has increased in the last years, in many different areas, being agriculture and forestry those who benefit the most from this relatively new remote sensing platform. Leaf area index, canopy and plant volume are among the parameters that can be determined using the very high resolution aerial data obtained by sensors coupled in unmanned aerial vehicles (UAV). This remote sensing technology affords the possibility of monitoring the vegetative development, identifying different types of issues, enabling the application of the most appropriated treatments in the affected areas. In this paper, a methodology allowing to perform multi-temporal UAS-based data analysis obtained by different sensors is proposed. A case study in vineyards and chestnuts is used to prove the benefits of continuous crop monitoring in its management and productivity of agroforestry parcels/activities.

Keywords: UAS; vineyards; chestnuts; multi-temporal data analysis; precision agriculture

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1. Introduction

Remote sensing platforms in precision agriculture (PA) have been applied for several years by the usage of different platforms such as satellites or manned aircrafts. Lately with the appearance of Unmanned Aerial Systems (UAS), that can be remotely piloted or have a programmed route to perform autonomous flight, new possibilities are offered in the remote sensing field. Generally, UASs also requires a ground-control station, sensor suites and communication devices for carrying out flight missions[1]. PA is a concept based on observing, measuring and responding to inter and intra-field variability in crops. The goal of PA is to define a decision support system for farm management with the goal of optimizing returns on inputs while, at the same time, preserving resources[2]. To achieve this, a fast, reliable, cost-effective and easy method to scan the fields is required. The crop's condition can be assessed by the stage of ripening, water status, pest attacks and nutritional requirements. The remote sensing capabilities acquired by UAS can provide this necessary data, so that the farmer is able to identify problems in early stages and rapidly select the appropriated interventions[3]. PA relies on four main tasks: data acquisition; terrain variability mapping; decision making; and application of management practices[4]. Remote sensing can be used with great benefit in the first three tasks. Acquiring the necessary information is one of the key factors of PA to provide correct support in the decision-making process and recognition of temporal variations[5]. The use of Unmanned Aerial Vehicles (UAV) can help to determine parameters such as leaf area index (LAI), crop cover, volume or height. Providing a flexible access to crop parameters such as vegetative vigour, quality and yield estimation[6].

This study proposes a methodology capable of analysing very high resolution UAV-based data from different types of sensors in a multi-temporal perspective, focusing on two different crops of great economic impact in Portugal, vineyards (*Vitis vinifera* L.) and chestnut trees (*Castanea sativa* Mill.). Where considerable areas of these crops are present in the northern region of the country[7]. The commercial value of these plantations depends on several factors such as: the caste (vineyards), the plant quality, and the climatic conditions of the region. However, in both crops, there are problems that may interfere with their development, which makes effective detection and inspection techniques necessary to decrease the occurrence risk of those problems, thus enabling a viable and sustainable cultivation of these crops. Nowadays, direct ground observations are performed to assess the presence of issues. In the vineyard, there are diseases for which it is necessary to eliminate many plants from the parcel or in some cases, to eliminate the whole parcel[8]. Regarding chestnut trees, problems such as Chestnut ink and Chestnut blight are the main causes of its decline[9]. For all these reasons, the detection of problems in earlier stages becomes indispensable, allowing a quicker response capacity to apply the proper treatment, saving up crops and reducing maintenance costs.

UAVs appear as the ideal tool, allowing the monitoring of crops through the analysis of spectral signatures and its vegetative development. The proposed methodology allows evaluating the temporal evolution of these cultures, determining the probable causes of potential problems, from biotic and/or abiotic origins, thus allowing the application of the most appropriate measures to eliminate/mitigate the identified problems.

This paper is structured as following: a brief overview of the related work in UAVs applied to agroforestry with a major focus on studies that used time-series data and data generated by each flight mission is provided in section two; in section three, the data analysis process is present and described; the fourth section, presents some preliminary results from the application of the proposed methodology; finally, section five presents some conclusions and provides the next steps implementing the proposed methodology.

2. Background

The technological development lead to the emergence of affordable and easy to operate small-sized UASs[10], making this platform suitable to be applied in different areas[11]. UAS allows the acquisition of very high resolution data using different types of sensors, with a greater versatility and cost-effectiveness than satellites or manned aircrafts in small/medium-sized projects[12]. The possibility to survey considerable areas in shorter time, providing very-high spatial and temporal resolutions images, makes UAS an ideal platform for monitoring agroforestry parcels[13]. In this specific sector, the UAS applicability goes from crop monitoring[13,14], invasive weed mapping[15], irrigation management[16–18], biomass[19–21], chlorophyll[22,23], and nutrient estimation[21,24] to vegetation height maps[25,26], among others. Different types of sensors operating in different parts of the electromagnetic spectrum (*i.e.* visible, red edge, near infra-red, thermal) can be used[10].