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Topographical map of infrastructures in forest areas and site inspections for nature development and protection, produced by using a low-cost Unmanned Aircraft Vehicles - evaluation case

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Abstract

Site inspections of the road network and the infrastructures in forest areas are crucial for development and protection of natural environment from several disasters such as forest fires. A digital topographical map can be an administrative tool to the Civil Protection and to Forest Offices for infrastructure inspection. The road network is usually inspected twice a year before the fire protection period by the forest service authorities, in order to record any abnormalities such as landslides and soil erosions and to secure the movement of the fire fighting vehicles. These inspections have major cost and working hours for the services' personnel. Due to the long length of the road-network the inspections are not carried out adequately and the implementation of repairs is delayed. This paper demonstrates the evaluation of a low-cost UAVs for the production of maps in order to implement photogrammetry analysis for observation of the functionality of road network. A case-study in the university forest of Taxiarchis - Chalkidiki, Greece is presented. Drone flights have taken place in the study area and orthophotos have been analyzed. The method is being compared with the regular in-situ methods in terms of cost and quality. Low-cost and fast inspection could ensure the damage repair and the safe movement of ground fire-firefighting vehicles.

Keywords: Topographical mapping, infrastructures, forest areas, UAV, natural development, hazards protection.

1. Introduction

Forest roads in general are not only engineering activities but also ecological actions that require careful planning, economic analysis, management of activities, to listen to the social demands to show a small ecological footprint to have the usability of the roads at multiple levels (transport of means, goods, people and services) (Stergiadis, Ch. 1982, Kantartzis, et all, 2021). Forest infrastructures in general, and road infrastructures in particular, play a key role in forest organization; forest utilization; and transportation of products, services, and maintenance (Alizadeh, et all, 2011).

A topographical map of infrastructures in forest areas can be an inspection tool to Forest Services for natural protection of hazards, everlasting development of forest or to prevent incidents like wild fires. The use of low cost Unmanned Aircraft Vehicles for producing ortho-photography of a forested area is the beginning of new era of field measurements in order to contact a topographical map. Surveying methods for producing a topographical map for landscape design (Setras et. All, 2021) or formation of public green areas or for Civil Protection Service requirements of for Forest Service project departments is the key question to research. UAV Remote Sensing Surveying, Total Station, and topographical mapping, where part of the process of image processing, the research of mosaic method and the field application of remote sensing technology were studied. The drone market is gaining traction at a high pace globally and commercial UAVs market is expected to grow over 19,9% of compound annual growth rate, or CAGR (as a mean annual growth rate of an investment over a specified period of time longer than one year- Wayman, 2021) until 2022.

A drone survey refers to the use of an unmanned aerial vehicle (UAV), to capture aerial data with downward-facing sensors, such as RGB or multispectral cameras, and LIDAR payloads. UAV aerial photogrammetry is widely used, mainly depends on the following characteristics of UAV aerial photogrammetry technology (Dibao et, all, 2018 and Hong, 2019). Recent advances in surveying technology allow to construct a novel, automated measuring platform using modern sensors and processing algorithms (Toth and Jo´z´ko´w 2016). Traditional geodetic survey techniques (total station and RTK/GNSS surveys) are nowadays more frequently replaced with high-resolution laser sensors and semi-automatic platforms: aerial light detection and ranging systems (ALS), terrestrial light detection and ranging systems (TLS) or mobile light detection and ranging systems

(MLS), personal laser scanning (PLS) (Marshall et al. 2016, Tomasz et all, 2018).

2. Methodology

2.1. Research area

The university forest of Taxiarchis Chalkidikis was chosen as researched area as an appropriate place to contact field measurements and to produce a recent and up-to-date digital map using low-cost UAVs; with all the infrastructure so that the current situation can be reviewed, while it is possible to use this data for sustainable forest management, prevention or suppression of possible hazards (floods, forest fires, tornadoes, etc.). A site inspection is crucial for forest areas such as Taxiarchis since it is part of the Cholomonta mountain, a Natura 2000 unique biotope protected area.

2.2. Methodology

A Phantom 4 pro v2.0 is chosen as our UAV for contacting the survey flight because it is considered a quality and low cost equipment. The methodology was used based on a) field routes b) field measurements with total station, c) UAV flight over the research area, d) geodetic data and base map indications (Figure 1). The reports of the process of creating an orthophoto with a UAVs are given in Figure 2. The survey data and the camera calibration are depicted. and the image locations plus the image overlap are being analysed. The Digital Elevation Model and the Orthophoto is presented after the mathematical solution of the mosaic created by the aerial photographs.

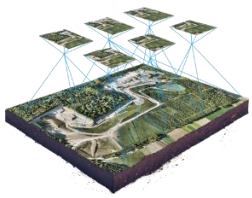

Figure 1. Serial photos in order to produce a mosaic for proceeding a topographical map

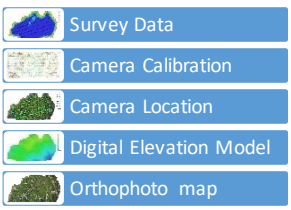

Diagram 1. Process of ortho-photo production using UAVs

Monitoring the selected area is a complex and long process requiring the follow-up of distinct and adapted methodological steps for each survey stage. The landslide monitored in the present study represents a risk in the territory, firstly on the residential complex of Student Dormitories developed as a result of the extension of the residential areas in the suburbs of Taxiarchis village, and secondly on the related infrastructures. Considering the potential risk impact as well as the high probability of occurrence due to forested area, it was decided to establish the development of the monitoring process based on a complex methodology.

The framework is interconnected with the two main methods of analysis, first the geodetic and topographic method that focus on the displacement evaluation of the points marked on the ground using precise measurements with Leica Viva Total Station and made from the staff of Institute of Mechanical Science and Topography of Department of Forestry and Natural Environment, A.U.Th. in 2017. Second, the UAV method which focuses on the analysis of changes in the configuration of the terrain based on geomatic techniques using the photos and GCPs obtained as a result of the flight missions from 2019, in order to obtain comprehensive results with a higher degree of accuracy and precision.

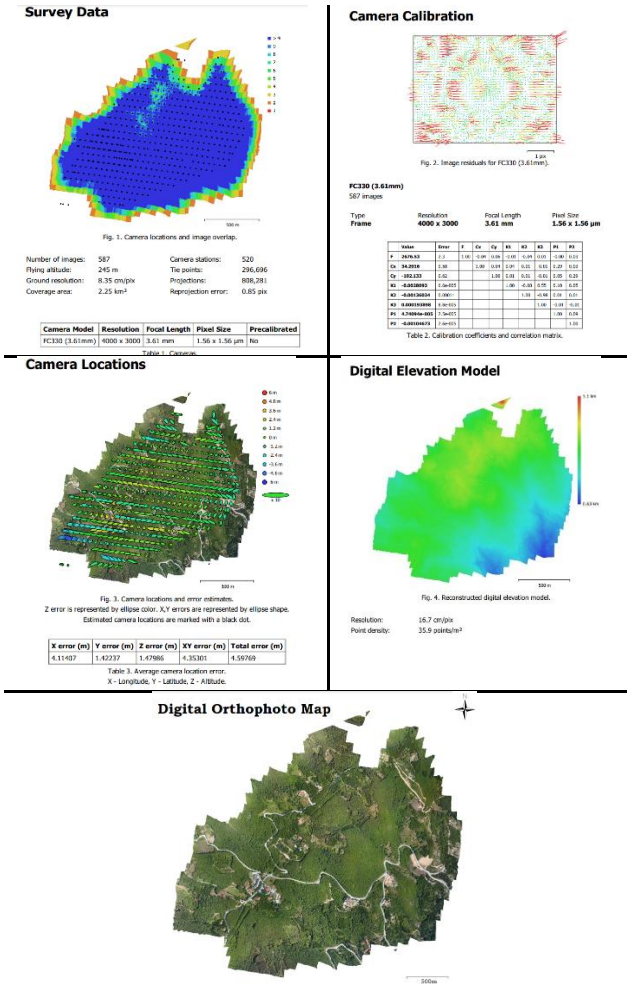

Figure 2. Working steps to produce a digital map via UAV

Using Phantom 4 Pro as a geodetically UAV and Pix4D program, we worked on the field and in the office in order to produce the following working steps that lead us to the topographical map of infrastructures in the forest area of of Taxiarchis University Forest at Chalkidiki. The idea was firstly to capture the area where the students of Forestry and Natural Environment Department are staying the summer period for their practical training, secondly we capture the water supply location or rainwater tanks and thirdly we divide the road network to local and forest roads. The knowledge of the locations of each infrastructure, the forest management of the area, the probability of occurrence of a natural hazard of wild fire and the use of the road network, water tanks as well as any

other type of infrastructure led us to capture all of the above through geodetic flight with UAVs.

3. Results

The results of the University Forest nearby the Forest Service offices and the Students Dormitories give as a monitoring of this area based on topographic-geodetic measurements and the 3D UAV modelling confirmed the fact that the analyzed areas' infrastructure can be a useful tool to the Forest Service as well as to the Civil Protection Service by means of decision-making tool (DMT). A digital map which produced by 3D UAV modelling represents the first level of a spatial analysis tool that can give opportunities to contact site inspections on the nearby constructions and infrastructures over summer period for forest fires prevention of winter period for flood disasters or snow fall. The usage of a UAV for monitoring at least four seasons in a year the University Forest of Taxiarchis can be a new way of a DMT because regular field observations provide a very effective means of monitoring and assessing probable hazards. These observations aim to measure displacements and deformations following natural disasters, thus helping to establish the evolution and the elaboration of the infrastructure damage forecast. The scientific investigations carried out in the research, presented in the first part of this paper and highlighted the importance and usefulness of the analyses regarding the risks of forest and nature protection. The information obtained through the use of UAV implementation and the spatial analysis carried out contributed to the understanding of the complex processes that manifest in the studied area, exhaustively completing the data and information obtained through field observations, field measurements, GIS infrastructure map and data interpretations.

The digital map of forest and local road network, the water supply locations and the residential complex of University Dormitories and Forest Service office can be the base tool to a spatial analysis for protection or suppression natural disasters. The knowledge of the road type, the speed that a vehicle of a firefighting department can move on that road can give us information about the duration of reaching the starting point of a forest fire.

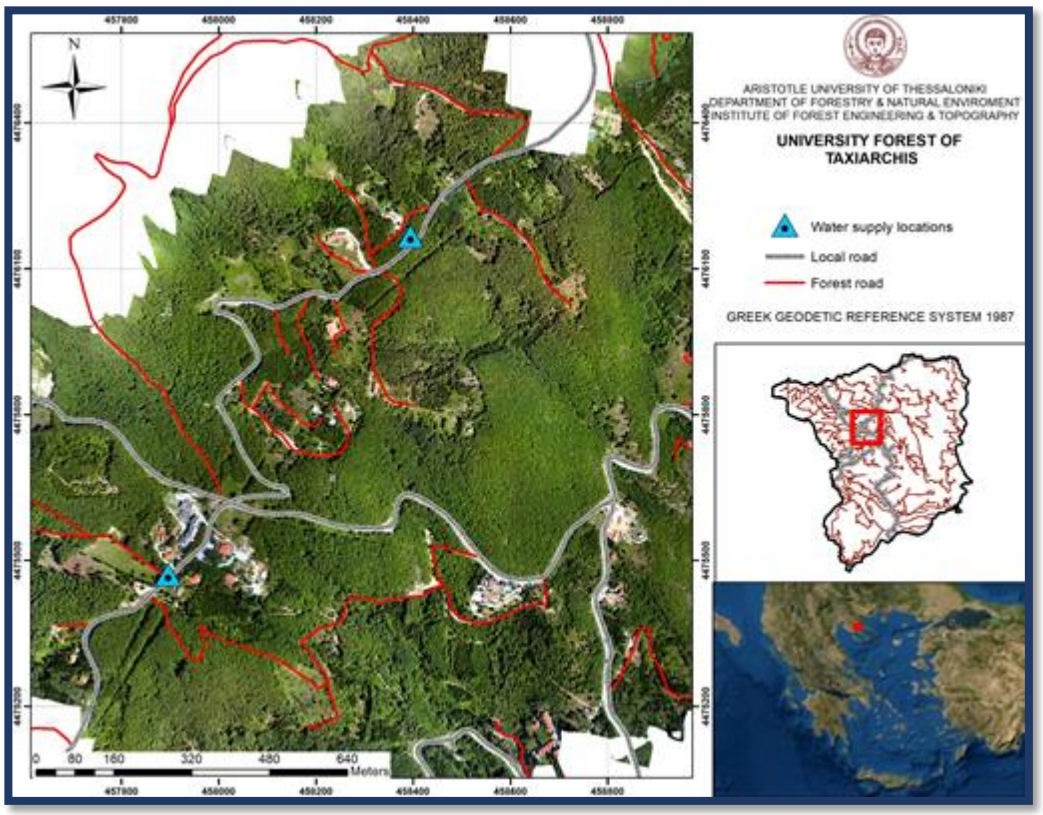

Figure 3. Digital Map of University Forest of Taxiarchis -Chalkidiki with infrastructures

4. Conclusions

The analysis of our results showed that continuous monitoring of forest areas such as the present can bring benefits as it works: 1) suppressive in case of forest fire, 2) preventive in case of frost, 3) recording failures or road damage, 4) recording possible ecological changes due to climate change, etc. We believe that the use of a low-cost UAVs, with geodetic potential can be a very useful tool in the hands of the Forest Service or Civil Protection, in order to act as a decision-making tool in case of natural disasters or site inspection of the infrastructures of a forest area.

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