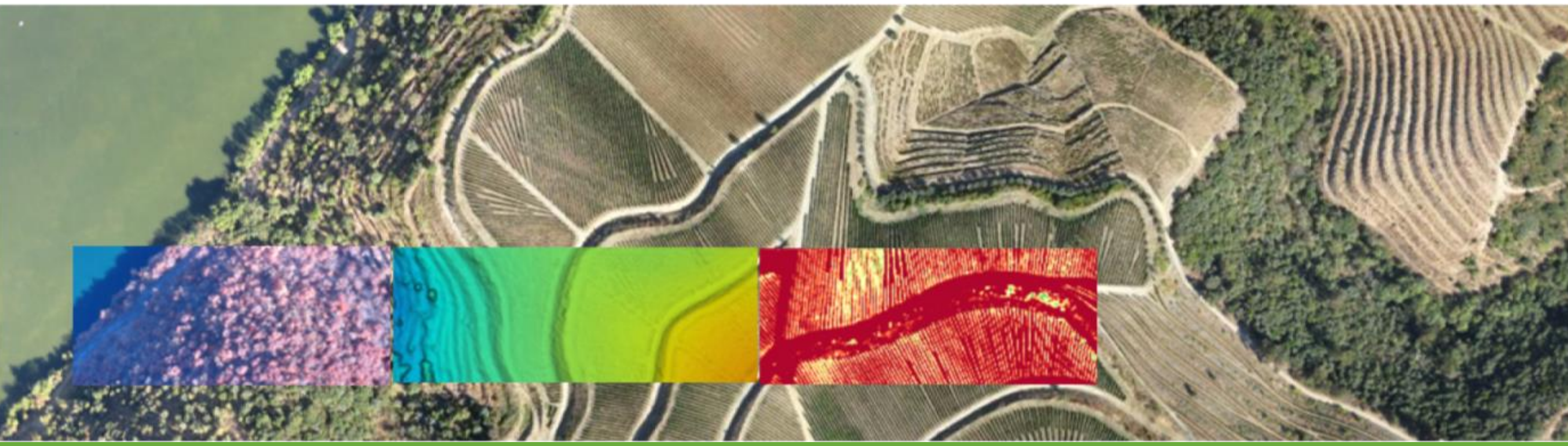
→UAS4Enviro2017

small Unmanned Aerial Systems for Environmental Research

5th Edition



ABSTRACT BOOK

28 – 30 June 2017 | UTAD | Vila Real, PORTUGAL

ISBN: 978-989-704-241-6

Abstract Book

UAS4Enviro2017

the 5th International Conference on

"small Unmanned Aerial Systems for Environmental Research"

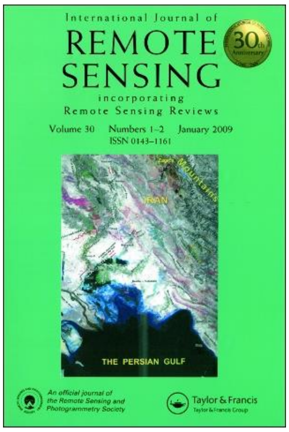
ISBN: 978-989-704-241-6

The use of civilian UAS for scientific applications is increasing rapidly around the world. In remote sensing, miniaturization of passive and active imaging sensors, improved navigation and georeferencing algorithms, coupled with the increased sophistication of analytical methods, has opened up new opportunities in environmental monitoring and management. In particular, UAS-based remote sensing offers unparalleled possibilities in ultra-high resolution imaging, as well as frequent and flexible custom data acquisition using both consumer-grade and professional sensors. It is no exaggeration to suggest that UAS technology is revolutionizing remote sensing.

UAS4Enviro 2017 is the 5th edition of the event since it follows previously very well attended and highly successful editions held in Worcester (2016), Liverpool (2015), Exeter (2014) and Worcester (2013). This three-day conference was composed by scientific presentations and a UAS Industry Day, featuring the latest developments and applications from remote sensing companies.

Around 100 participants, representing more than 20 nationalities (Europe, America and Asia and Africa), attended the event, from academia and industry, who are already working with drones, or who are curious to explore the latest developments and acquire the latest products in this field. (Follow the link for all information about the event http://www.uas4enviro.org).

The International Journal of Remote Sensing (IJRS) invites submissions of papers on Unmanned Aerial Systems for environmental research for consideration for publication in a special issue titled, Unmanned Aerial Systems (UAS) for Environmental Applications



(http://explore.tandfonline.com/cfp/est/unmanned-aerial-systems).

A core component of the special issue will be papers from the UAS4Enviro2017 conference.

We welcome submissions of papers arising out of work described at this conference as well as any other papers not presented at the conference however are related to the use of UAS in remote sensing, including papers oriented towards methods or environmental applications.

How to Submit your Manuscript

All submissions will be peer reviewed according to IJRS guidelines. Submitted manuscripts should not have been published or be under review elsewhere. Prospective authors should consult the Instructions for authors' page on the journal homepage for guidelines and information on paper formatting and submission.

Authors should submit their papers using ScholarOne Manuscripts™

Please choose 'IJRS Special Issue Paper' from the 'Manuscript Type' picklist on the submission form, irrespective of the paper type (i.e. even if your paper would normally be classified as a Research Letter, Technical Note, Research Paper, or Review Article). Also, please enter "UAS" in the space provided on the submission form for the name of the special issue.

The IJRS has no page charges, and also does not charge for printing in color. Open access publication is also possible, though a fee is charged for this. Click here for more information about open access options.

Important Dates

Deadline for the submission of contributions: September 30, 2017

Joaquim J. Sousa, UAS4Enviro2017 Chair

Remote Sensing and Phogrammetry Society:

The Remote Sensing and Photogrammetry Society (RSPSoc) is the UK's leading Society for remote sensing and photogrammetry and their application to education, science, research, industry, commerce and the public service. As a charity, its remit is to inform and educate its members and the public. It supports networking between the University, business and government sectors. An international society, RSPSoc is also active in Europe and on the world stage.

The RSPSoc gives you access to the world of remote sensing and photogrammery. The Society is involved with:

- the co-ordination and promotion of activities in remote sensing and photogrammetry;
- relationships and discussion with other related societies;
- the encouragement of commercial and government participation in remote sensing and photogrammetry;
- supporting education and training at all levels.

The Society fosters links between commercial, industrial, academic and international organisations and gives its members wider opportunities to exploit available technology and to combine their knowledge and skills. Its activities are relevant to individuals and groups interested in the:

- application of remote sensing and photogrammetric data to real world problems in design and development of new instrumentation, sensors and platforms for remote observation and measurement;
- development of novel techniques and methods for analysing remotely sensed and photogrammetric data;
- integration of remotely sensed and photogrammetric data with other spatial data;
- development of the commercial market for remote sensing and photogrammetric products and services;
- promotion of education in remote sensing and photogrammetry.

A key feature of the RSPSoc is the focus that it provides for the exchange of knowledge and expertise in remote sensing and photogrammetry.

For more information speak to any committee member during the conference, or contact:

Judy Barson,
The Remote Sensing and Photogrammetry Society,
c/o Department of Geography,
The University of Nottingham, University Park,
Nottingham, NG7 2RD, United Kingdom

Website: **www.rspsoc.org.uk**
Email: **rspsoc@rspsoc.org**
Tel: **+44 (0)115 951 5435**;

The International Society for Photogrammetry and Remote Sensing (www.isprs.org) is a non-governmental organization devoted to the development of international cooperation for the advancement of photogrammetry and remote sensing and their applications.

Photogrammetry and Remote Sensing is the art, science, and technology of obtaining reliable information from noncontact imaging and other sensor systems about the Earth and its environment, and other physical objects and processes through recording, measuring, analyzing and representation.

isprs

information from imagery

Table of Contents

ORGANIZING COMMITTEE I

SCIENTIFIC COMMITTEE I

THE INTEGRATION OF UAS IN INTERNET OF THINGS FOR CONSERVATION BIOLOGY 1

POSITIONAL ACCURACY IN ENVIRONMENTAL PHOTOGRAMMETRIC PROJECTS USING LOW-COST MINI-UAS SYSTEMS 2

MAPKITE: A NEW CONCEPT FOR INFORMATION ACQUISITION IN ENVIRONMENTAL MAPPING PROJECTS 11

THE EFFECT OF SPATIAL RESOLUTION OF UAS-BASED THERMAL IMAGERY ON TURBULENT HEAT FLUX ESTIMATES 18

MULTI-SEASONAL MONITORING OF ACACIA LONGIFOLIA THROUGH UAS: POTENTIAL FOR DETECTION OF A BIOCONTROL AGENT 20

USING MULTITEMPORAL UAV IMAGERY TO ESTIMATE TREE HEIGHT GROWTH IN *PINUS PINEA* PLANTATIONS IN PORTUGAL 21

GENERATION OF CANOPY HEIGHT MODEL BASED ON POINT CLOUDS AND SPECTRAL DATA: A CASE STUDY ON GRAPEVINE 23

USING UNMANNED AERIAL VEHICLES TO DETECT FLOWERING OF AN INVASIVE TREE AS A PROXY TO ASSESS THE EFFICIENCY OF A BIOCONTROL AGENT 24

CLIFF VEGETATION MONITORING USING CLOSE RANGE PHOTOGRAMMETRY AND UAS: TECHNICAL ISSUES AND PRACTICAL HINTS 25

USE OF 3-D HYDROLOGIC MODELLING AND UAV-PHOTOGRAMMETRY TO CHARACTERIZE THE PHYTOEXTRACTION EFFICIENCY OF POPLAR TREES IN A CADMIUM CONTAMINATED AGRICULTURAL FIELD 29

CHESTNUT HEALTH MONITORING BY AERIAL PHOTOGRAPHS OBTAINED BY UNNAMED AERIAL VEHICLE 31

AUTOMATIC CHESTNUT TREES MONITORING BY AERIAL PHOTOGRAPHS OBTAINED BY UNNAMED AERIAL VEHICLE 32

VINEYARD DETECTION FROM THE COMBINATION OF RGB AND RED EDGE-BASED UAS IMAGERY 34

EVALUATION OF WINTER CROP DAMAGE USING UAV-BASED MULTISPECTRAL IMAGERY 36

UAS-BASED HYPERSPECTRAL SENSING METHODOLOGY FOR CONTINUOUS MONITORING AND EARLY DETECTION OF VINEYARD ANOMALIES 37

HYDRONES: A NEW SERVICE FOR MONITORING WATER BODIES, APPLICATION TO THE OBSERVATION OF A TIDAL BORE IN THE GARONNE RIVER 42

ADVANCED REFRACTION CORRECTION FOR UAV-SFM MODELS OF RIVERS: A CASE STUDY FROM THE RIO PALANCIA, SPAIN 43

COMBINING UAV PHOTOGRAMMETRY AND OPEN SOURCE SOFTWARE FOR FAST AND EFFECTIVE ASSESSMENT OF COASTAL EROSION – THE CASE STUDY OF SOUTH COVA DA GALA'S BEACH, PORTUGAL 44

RPAS AS A NEW TOOL FOR THE STUDY OF SAND DUNES IN COASTAL ENVIRONMENTS: A CASE STUDY IN THE SOUTH ATLANTIC AREA OF SPAIN 45

UAS AS TOOLS FOR RAPID DETECTION OF STORM-INDUCED MORPHODYNAMIC CHANGES AT SANCTI PETRI SPIT, SW SPAIN 46

VERY HIGH-RESOLUTION AEROPHOTOGRAMETRIC SURVEY OF THE 2014/2015 LAVA FLOW FIELD OF FOGO VOLCANO (CAPE VERDE) 49

LEVEE RISK AREA DETECTION BASED ON THE UAS PLATFORM DATA - INTEGRATION OF MULTISPECTRAL IMAGERY AND LIDAR POINT CLOUD 51

UAS-BASED CHANGE DETECTION OF THE LÄRCHBERG-GALGENWALD LANDSLIDE, AUSTRIA 52

UAS IDENTIFICATION OF LIANA INFESTATION IN TROPICAL FORESTS, MALAYSIA 55

USING A UAV TO MONITOR TEMPERATE INTERTIDAL HABITATS: AN ASSESSMENT OF PHOTOGRAMMETRY AND OBJECT-BASED IMAGE ANALYSIS 57

CAN DRONES BE USED TO ESTIMATE ORANGUTAN DENSITIES? 58

ADAPTING ASTRONOMICAL SOURCE DETECTION TECHNIQUES TO DETECT UNRESOLVED ANIMAL SOURCES IN THERMAL IMAGES OBTAINED BY UNMANNED AERIAL SYSTEMS 59

TESTING THE FEASIBILITY OF UNMANNED AERIAL VEHICLES AND THERMAL IMAGING FOR UNGULATE SURVEYS 60

UAV BASED SURVEY OF THE WEST ANTARCTIC ENVIRONMENT 61

UAV TECHNOLOGY FOR DETECTION AND CHARACTERIZATION OF PATOLOGIES IN PLATES OF THE CONCRETE COVERING OF SLOPES 62

ASTRONOMY MEETS CONSERVATION BIOLOGY: THERMAL PROFILING AS A TOOL FOR THE AUTOMATED CLASSIFICATION OF SPECIES IN UAVS THERMAL FOOTAGE ANALYSIS PIPELINE 64

QUANTIFYING AND VALIDATING RAPID GEOMORPHIC EVOLUTION, A MONITORING AND MODELLING CASE STUDY 65

CRUCIAL FACTORS TO CONSIDER DURING THE ASSESSMENT AND PROCUREMENT OF DRONE SYSTEMS FOR FORESTRY, CONSERVATION AND ENVIRONMENTAL APPLICATIONS EXEMPLIFIED IN THE CASE OF THE SETUP OF A MONITORING SYSTEM FOR A REGIONAL CONSERVATION AREA IN SAN MARTIN, PERU. 66

EVALUATION OF URBAN GREEN SPACES WITH UAV-BASED PHOTOGRAPHY, IN QUITO, ECUADOR 67

HIGH RESOLUTION MAPPING OF GEOMORPHOLOGICAL HAZARD EXPOSURE OF ANTARCTIC INFRASTRUCTURES USING UAVS 70

DEVELOPMENT OF QGIS PLUGIN TO OBTAIN PARAMETERS/ELEMENTS OF TREETOPS WITH UAV IMAGERY 71

UAV APPLICATION FOR FAST PATHFINDING IN ANTARCTIC EXPEDITION 73

PRECISION ENGINEERING FOR GULLY EROSION CONTROL WITHIN THE HUMID TROPICS OF NIGERIA: A REMOTE SENSING APPROACH 74

CHANGE ASSESSMENT OF THE DOURO SAND SPIT USING FIXED WING UAVS 75

USING A UAS FOR ENVIRONMENTAL MONITORING OF THE MARINE ENVIRONMENT 76

TOWARDS AN UNMANNED SYSTEM OPTIMIZED FOR INVASIVE PLANT SPECIES MAPPING 78

HABITAT EXTENT AND CONDITION ASSESSMENT USING MULTISPECTRAL REMOTELY PILOTED AIRCRAFT SYSTEM IMAGERY IN THE NW MOUNTAINS OF GALICIA (NW SPAIN) 79

TARGET INFLUENCE IN GROUND CONTROL POINT IDENTIFICATION USING HIGH RESOLUTION AERIAL IMAGES 83

CHARTS FOR DETERMINING FLIGHT HEIGHT AND SPEED FOR UAV PHOTOGRAMMETRIC FOREST MAPPING 85

ACCURACY ASSESSMENT OF POINT CLOUDS FROM LIDAR AND IMAGE MATCHING ACQUIRED WITH THE UAS PLATFORM 86

SMART COVERAGE PATH PLANNING: ENERGY EFFICIENCY IN SMALL UNMANNED AERIAL VEHICLES SYSTEMS (S-UAVS) 87

DELINEATION OF RILL SOIL EROSION FROM UAV-BORNE REMOTE SENSING DATA 88

ADAVANTAGES OF USING UAVS DATA TO STUDY ROCKY COASTS GEOMORPHOLOGY: THE CASE STUDY OF THE SÃO PAIO ROCKY LITTORAL, PORTUGAL 90

UAVS DATA FOR MONITORISING RESCUE ARCHAEOLOGICAL EXCAVATIONS: RODO, BISPEIRA 8 AND VAU SITES IN RIBEIRADIO RESERVOIR, VOUGA CATCHMENT (PORTUGAL) 94

UAVS ORTHOIMAGES FOR IDENTIFYING AN MAPPING GEOMORPHIC INHERITANCE OF THE QUATERNARY GLACIERS AT THE SOAJO-PENEDA MOUNTAIS, PORTUGAL 98

RPAS FOR PRECISSION GREENKEEPING AND IMPROVED WATER MANAGEMENT IN GOLF COURSES 102

THE RIGHT UAS FOR YOUR AGROFORESTRY APPLICATION: A WEB-BASED DECISION SUPPORT SYSTEM 103

A UAV AND SFM APPROACH AS A FAST AND COMPLETE METHODOLOGY ON MORPHOSTRUCTURAL ANALYSIS 107

THE TALES OF AKERATEHEILS – CAN RPAS BASED MAPPING OF ANCIENT GRAVES IMPROVE OUR UNDERSTANDING OF THE BLEMMY CULTURE? 109

UAVS FOR SUSTAINABLE FORESTRY 111

COMPARISON OF POINT CLOUDS OBTAINED FROM TERRESTRIAL LIDAR (TLS) AND UAV VERTICAL SURVEYING IN FORTE NOVO BEACH AND CLIFF (QUARTEIRA, PORTUGAL) 112

COMBINING UAS AND HISTORICAL AERIAL IMAGERY SFM PHOTOGRAMMETRY FOR CULTURAL HERITAGE DOCUMENTATION AND RESEARCH: THE CASE OF TORRE DE MODORRA (VINHAIS, NORTHERN PORTUGAL) 113

UAS PHOTOGRAMMETRY FOR THE GEOARCHAEOLOGICAL SURVEY OF ANCIENT MINING LANDSCAPES 115

CHANGE DETECTION AND SPATIAL DYNAMICS OF LAND COVER DEGRADATION IN THE SOUTH EAST AURÈS (ALGERIA) 116

THE TREE OBSERVATORY AS A TEST BED FOR UAS APPLICATIONS TO STUDY TREES 117

PHOTOGRAMMETRIC ANALYSES FOR HIGH RESOLUTION BATHYMETRYOF THE GEPATSCH RESERVOIR (TYROL, AUSTRIA) 118

DEEPEYE: A UAS-BASED DEEP LEARNING FRAMEWORK FOR DETECTING DAMAGED BUILDINGS 121

THE MAPP PLATFORM: REMOTE SENSING FOR AGRICULTURE BASED ON SATELLITE AND DRONE DATA 122

UAVS - REGULATIONS AND LAW ENFORCEMENT 124

ORGANIZING COMMITTEE

António Sousa / UTAD	|	amrs@utad.pt
Emanuel Peres / UTAD	|	eperes@utad.pt
Francisco Pereira / UTAD	|	fsp@utad.pt
Joaquim João Sousa / UTAD	**|**	**jjsousa@utad.pt, (Chair)**
José Sousa / UTAD	|	jmsousa@utad.pt
Ricardo Bento /UTAD	|	rbento@utad.pt

SCIENTIFIC COMMITTEE

Pedro Pina / IST, Lisboa, Portugal

Renato Henriques / UMinho, Portugal

Rolf Becker Rhein-Waal / University of Kleve, Germany

Rui Pedro Julião / New University of Lisbon, Portugal

Sergio Molina Blázquez / Tragsatec, Spain

Stuart Phinn / University of Queensland, Australia

THE INTEGRATION OF UAS IN INTERNET OF THINGS FOR CONSERVATION BIOLOGY

Margarita Mulero-Pázmány(1), Ramiro Martínez de Dios(2), Richard Figura (3), Chia-Yen Shih(3), Marc Schwarzbach(4), Francisco Alarcón(5), Andrea Kropp(6), Héctor Nebot(7), Janek Mann(8), Emilian Radoi(8) Gianluca Dini(9), Antidio Viguria(5), Juan José Negro(10), Aníbal Ollero(2,5), Pedro José Marrón(3).

(1) Departamento de Ciencias Naturales. Universidad Técnica Particular de Loja. San Cayetano Alto, Loja, Ecuador, muleromara@hotmail.com

(2) Robotics, Vision and Control Research Group, University of Seville, Spain.

(3) Networked Embedded Systems, University of Duisburg-Essen, Germany.

(4) Robotics and Mechatronics Center, German Aerospace Center DLR. Germany.

(5) Center for Advanced Aerospace Technologies (CATEC), Spain

(6) SELEX ES, Italy

(7) ETRA Research and Development, Spain

(8) University of Edinburgh, UK

(9) Department of Ingegneria dell'Informazione, University of Pisa, Italy

(10) Doñana Biological Station, CSIC, Spain

Key-Words: "environmental monitoring"; "drones"; "UAS; "Internet of things"; "pollution"

ABSTRACT:

In recent years, Unmanned Aircraft Systems (a.k.a. UAS, drones or RPAS) have been incorporated to environmental studies thanks to the exponential growth of the market, the decline on prices and technological advances that make the systems easier to operate. Small UAS can be deployed almost anywhere at any moment and equipped with different sensors that allow gathering detailed spatio-temporal information of high value for studies in conservation biology. Heterogeneous sensor networks, also known as Internet of Things have also started to play a major role in environmental studies because they allow recording abundant and diverse data in large-scale scenarios that are characteristic from natural protected areas with little human effort.

This communication presents the unprecedented possibilities that the combination of both technologies offer for environmental monitoring and protection. In addition to traditional image gathering from drones, we also exploited their innovative robotic capabilities for collecting samples and download data from tagged animals. We describe some examples of UAS integration in sensor networks addressing environmentally relevant applications such as pollution detection and wildlife monitoring that were developed and tested in natural protected areas.

POSITIONAL ACCURACY IN ENVIRONMENTAL PHOTOGRAMMETRIC PROJECTS USING LOW-COST MINI-UAS SYSTEMS

Gómez-López, José Miguel[(1)] , Pérez-García, José Luis[(1)], Delgado-García, Jorge [(1)]

[(1)] Dpto. Ingeniería Cartográfica, Geodésica y Fotogrametría, Universidad de Jaén, Campus de las Lagunillas, Edif. A-3. 23071 Jaén (Spain), Email: jglopez@ujaen.es, jlperez@ujaen.es, jdelgado@ujaen.es

Key-Words: Photogrammetry; UAS; Positional Accuracy; Digital Elevation Models; Orthoimages

ABSTRACT:

In recent years, there has been a significant growth in the use of UAV systems in various areas related to the capture of information in the territory, the number of equipment available in the market is increasing and several reports show a significant boom of the sector in the coming years. Undoubtedly, we are facing a new revolution in Photogrammetry, after that lived in 1990s that was defined as the “democratization of photogrammetry” [1] using digital photogrammetric systems and the so-called “desktop mapping”, facilitating to many users the access to the tasks of photogrammetric treatment of the images and the obtaining of mapping products. With UAS, in particular mini-UAS, the user can complete the entire process by performing the image capturing tasks, being a very important tool when the areas to be covered have a small extension and an important detail level is required in the captured images (as well as in the derived information).

This revolution is supported by an ever-increasing supply of equipment and systems, many of them low-cost ones (around $1000-1500) and easy-to-use information processing systems that incorporate modern methodologies for image orientation, dense 3D points cloud and 3D realistic models generation and orthoimages. These systems usually incorporate a high level of automatism and a limited control of certain procedures that can give rise to problems in the geometric quality of the obtained products, sometimes masked in the own generated reports in which everything seems to be correct. There errors could be especially important in environmental studies in which the temporal evolution of a phenomenon is considered. In these cases are usually to made several captures over time, and it is especially important, verification of the positional accuracy of the generated products, to so as not to reach erroneous conclusions about them.

In this work, different aspects that have an important influence on the final positional accuracy of the generated products (digital elevation models -dense 3D point clouds- and orthoimages) are analysed. The objective is to provide a complete guide of what to do and how to do it, and the problems that can arise when these recommendations are not taken into account.

A total of 2 study areas has been considered, with different characteristics as regards the relief present in them (Espeluy, flat area, and Jamilena, moderate relief area) (fig. 1 and tab. 1). In both cases, a low-cost mini-UAV was used for image capture (DJI Phantom 3 Standard [2]) obtaining images with GSD around 0.05m (in Espeluy area, two different flight heights with transversal strips were considered). In both areas information is available from an ALS system (aerial laser system) that has been used as a reference element.

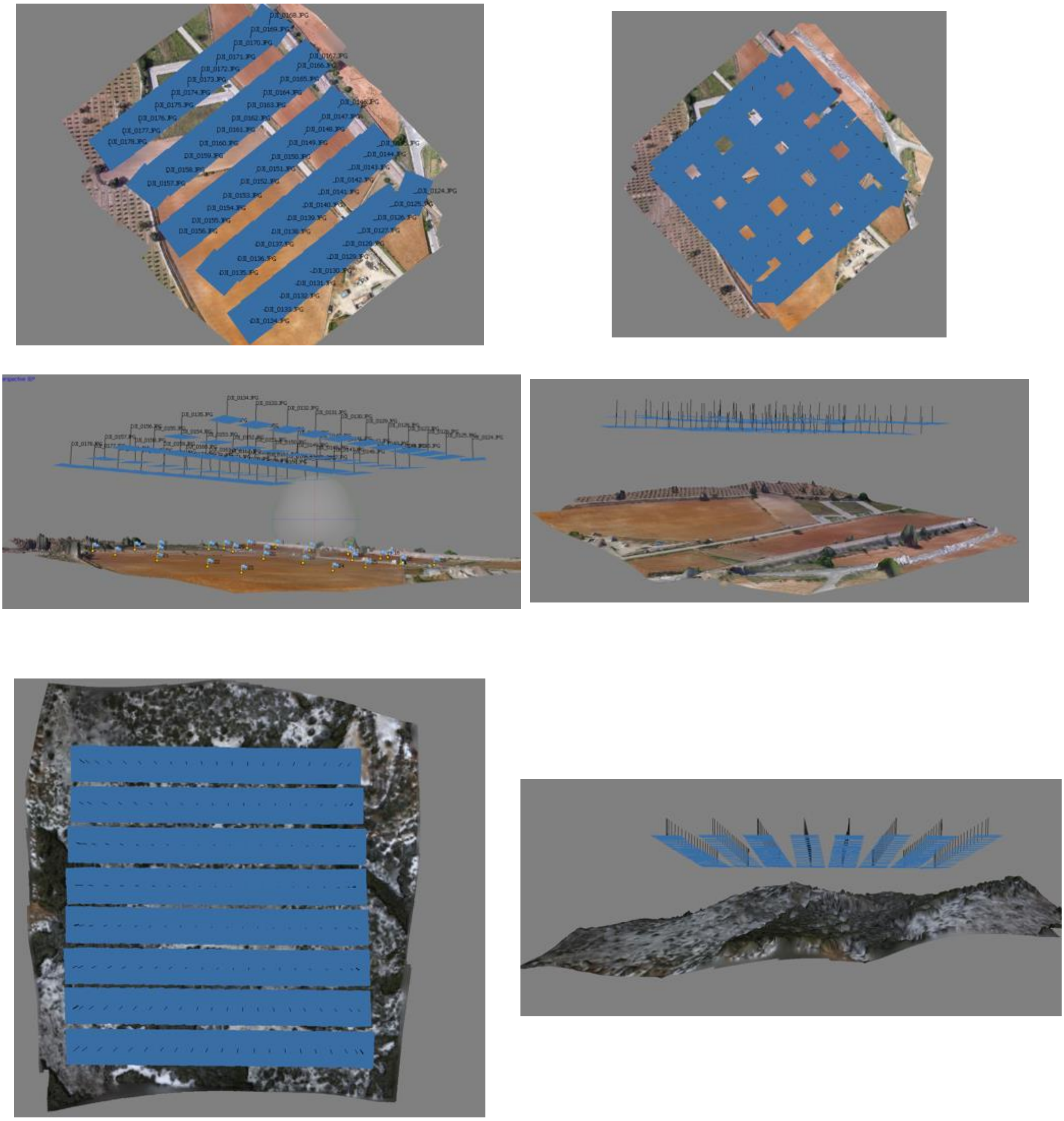


Figure 1. Study areas and flight missions. Top, Middle: Espeluy area; bottom: Jamilena area

Area	Mean GSD (m)	Strips	Total images	Overlap(%)	No. GCP
Espeluy	0.045	5/10	55/103	80/60	26
Jamilena	0.06	8	182	80/60	21

Table 1. Study areas and flight missions. Top: Espeluy area; bottom: Jamilena area

In both cases, a high number of control points have been measured using high precision GNSS devices. The distribution of the points is shown in fig. 2. These points were pre-signalized on the ground in order to facilitate their location and improve their measurement. Considering these points have been considered variable schemes of distribution of points, as to their number from not using any (direct orientation), to consider 1, 4 (corners), 6, 9 and all points. In all cases, the orientation of the blocks was carried out using Agisoft PhotoScan v.1.3.2 [3] software, and no significant problems in the block orientation reports have been obtained. However, when products are generated and compared with the reference models (obtained from ALS data) several problems are observed.

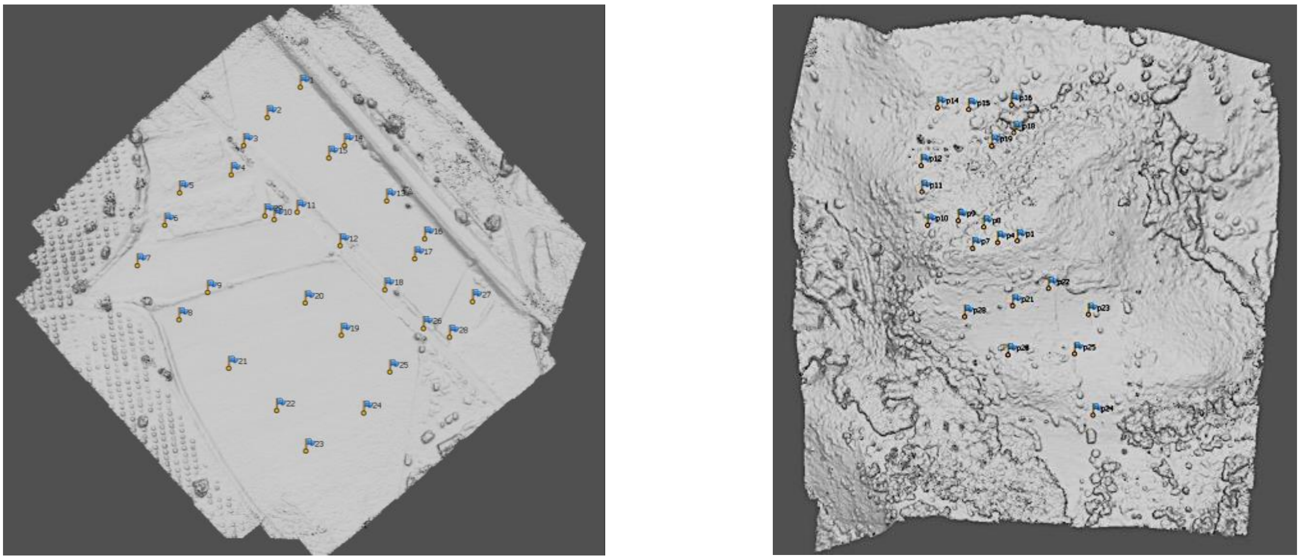


Figure 2. Ground/check control points (GCP) distribution. Left: Espeluy area; right: Jamilena area

The first issue to be taken into account is the importance of having adequate camera parameters (camera constant, principal point coordinates and distortion parameters). For this, it is necessary to use a laboratory calibration of the camera or to apply self-calibration procedures. Problems have been detected in self-calibration procedures especially when the terrain is flat (Espeluy area) and the GCP is reduced. Thus, the differences between the obtained and reference 3D point clouds are shown in fig. 3, showing important differences in the central zone (bulging). Basic statistics for these models are presented in tab.2.

An important aspect to consider is the influence of the relief of the study area in the self-calibration procedure. If the area has an important relief the adjustment of these parameters will be easier, achieving a better adjustment between the calculated values and the actual values of the camera. This results in more realistic models, even with a reduced number of control points. Thus, in the Jamilena area, the differences detected between the use of precalibrated chambers and self-calibration procedures are small even using a reduced number of support points (4) (fig.4 and tab.3), unlike the previous section.

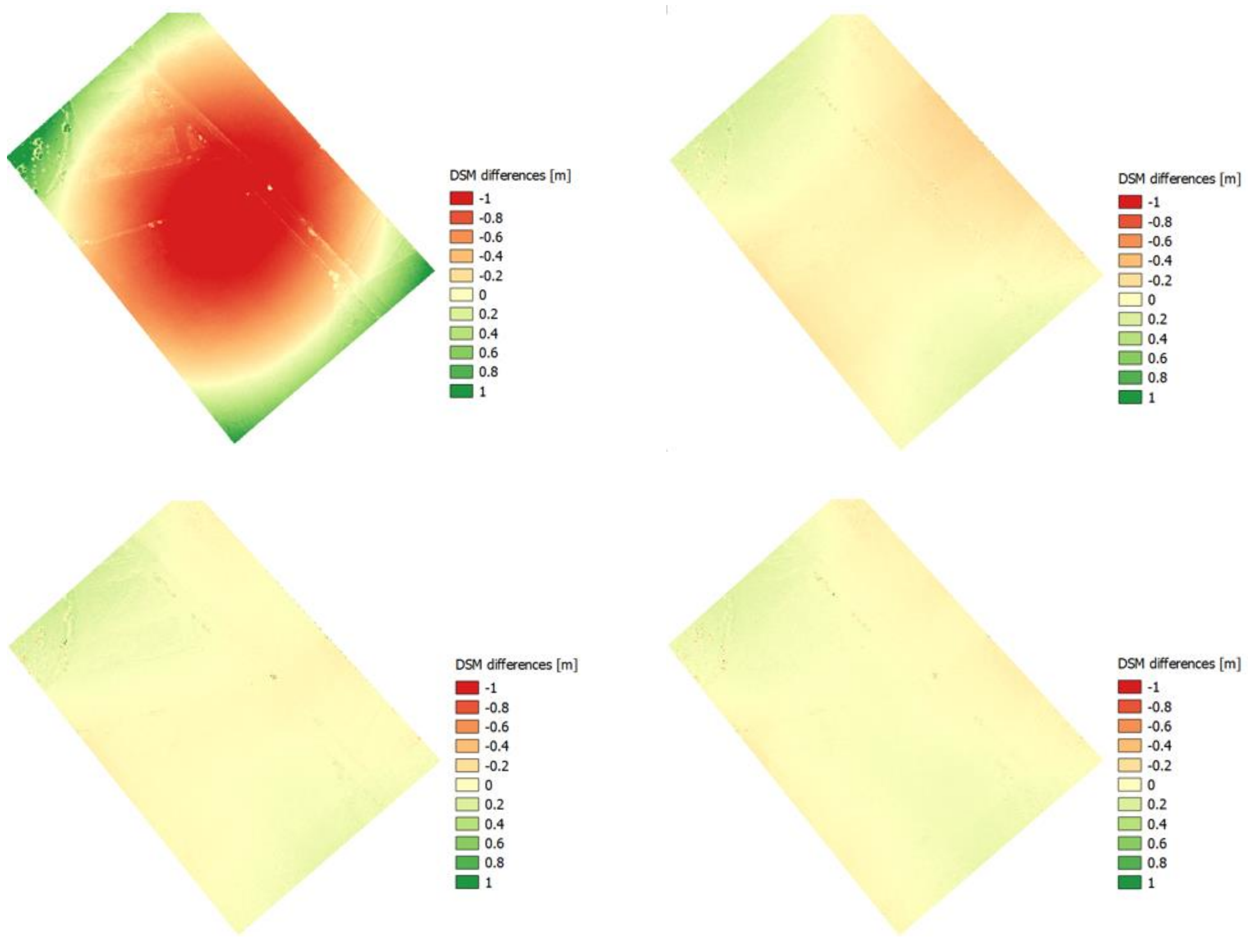


Figure 3. DSM differences –Espeluy area-. Top: 4GCP left, self-calibration; right, precalibrated camera; Bottom: 6 GCP left, self-calibration, right, precalibrated camera.

No.GCP	Self-calibration	DSM Differences (m)				
		Mean	Std.Dev.	Q1	Q3	IQR
4	Yes	0.374	0.541	-0.814	0.038	0.852
	No (precalibrated)	-0.025	0.105	-0.089	0.040	0.129
6	Yes	0.012	0.063	-0.024	0.043	0.067
	No (precalibrated)	0.019	0.179	-0.022	0.042	0.063

Table 2. Basic statistics of the DSM differences (m) –Espeluy area-

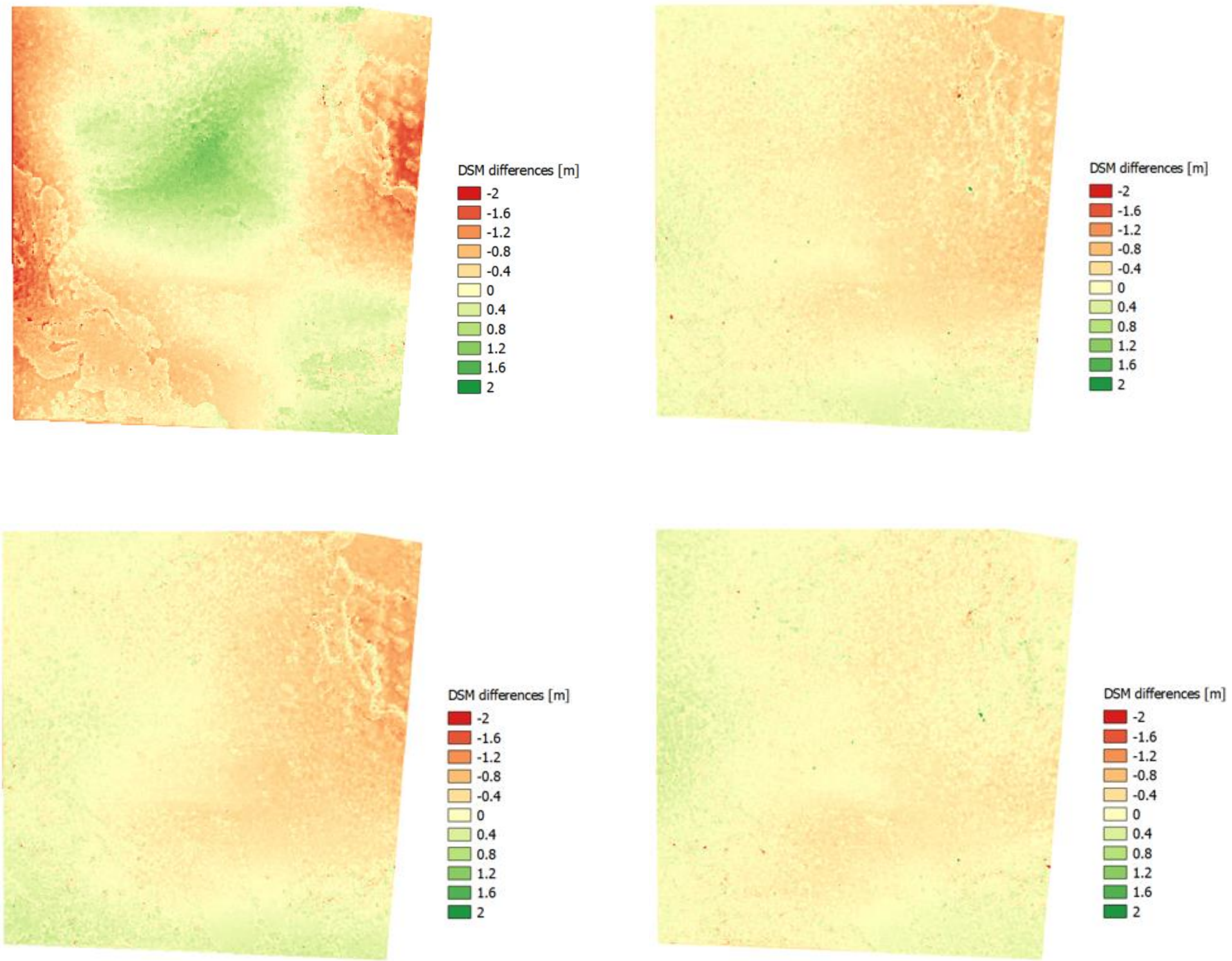


Figure 4. DSM differences –Jamilena area-. Top: 4GCP left, self-calibration; right, precalibrated camera; Bottom: 6 GCP left, self-calibration, right, precalibrated camera.

No.GCP	Self-calibration	DSM Differences (m)				
		Mean	Std.Dev.	Q1	Q3	IQR
4	Yes	-0.149	0.581	-0.495	0.218	0.712
	No (precalibrated)	-0.112	0.316	-0.288	0.074	0.363
6	Yes	-0.094	0.355	-0.294	0.138	0.432
	No (precalibrated)	0.068	0.311	-0.176	0.222	0.398

Table 3. Basic statistics of the DSM differences (m) –Jamilena area-

Finally, an analysis of the positional accuracy of the orthoimages has been made. The orthoimages have a good visual quality (radiometric and geometric continuity) (fig.5) but it is clear that the DSM errors must be reflected in their positional quality, despite using high overlap values (80/60) used in the flights. RMS and CE95 [4],[5] have been for each area and orientation configuration, through the check points measurement in the orthoimages. The results are shown in tab. 4 and fig.6 and 7, showing the influence on the quality of the products.

In Espeluy area (flat area), CE95 values for 0 GCP configuration (DiSO) are around 7m, both self-calibration and precalibrated configuration, using 1 GCP these values are reduced to 2.6m and 1.3m respectively. Using a larger number of GCP (4, 6 or 9) the CE95 values for precalibrated camera is around 0.2m, but self-calibration configure descends more slowly (0.3, 0.25 and 0.2 m). In Jamilena area, although a priori might seem to be more complicated as a consequence of its greater relief, it can be observed that the results when convergence is obtained (correct block orientation) are better with CE95 values around 0.13m (using precalibrated camera configuration), even CE95 values are obtained below 0.2m, with a reduced number of control points (4 for the precalibrated camera and 6 for the autocalibration configuration). As in the Espeluy zone, errors when direct orientation (0 GCP) or 1 GCP are used, are in the order of 7-8m if self-calibration and 3-4m precalibrated camera are used.

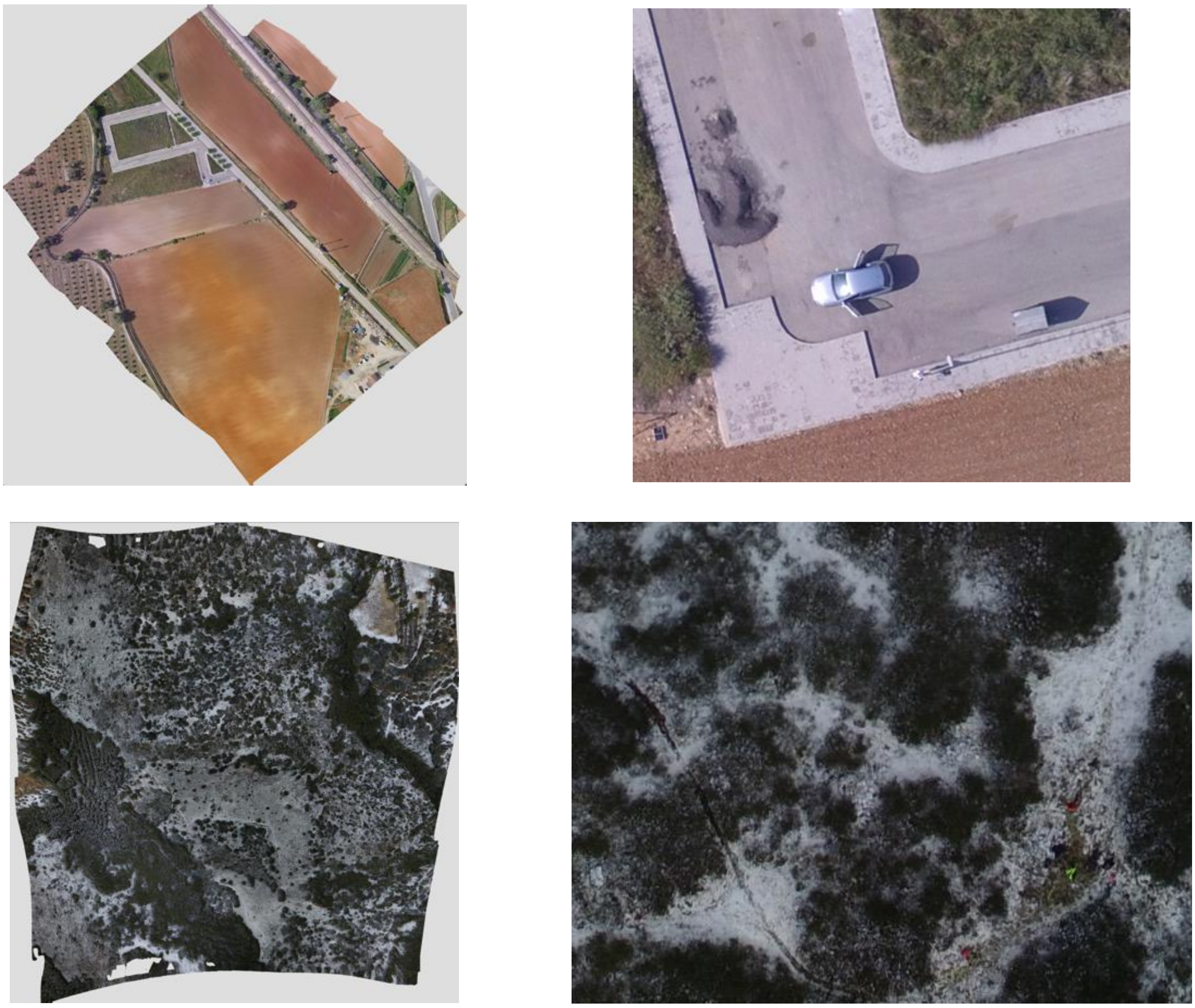


Figure 5. Orthoimages. Top: Espeluy area, Bottom: Jamilena area. Left: General view, right: detailed view

Area	No.GCP	Self-calibration	RMSx(m)	RMSy(m)	CE95(m)
Espeluy	0	Yes	1.821	4.053	7.188
		No (Precalibrated)	2.028	3.752	7.073
	1	Yes	1.136	1.026	2.646
		No (Precalibrated)	0.636	0.406	1.275
	4	Yes	0.126	0.124	0.306
		No (Precalibrated)	0.104	0.075	0.219
	6	Yes	0.103	0.114	0.265
		No (Precalibrated)	0.086	0.085	0.209
	9	Yes	0.093	0.106	0.244
		No (Precalibrated)	0.082	0.086	0.205
	27	Yes	0.078	0.066	0.176
Jamilena	0	Yes	3.042	3.520	8.030
		No (Precalibrated)	0.221	2.040	2.767
	1	Yes	1.895	3.852	7.034
		No (Precalibrated)	1.207	2.267	4.252
	4	Yes	0.091	0.096	0.228
		No (Precalibrated)	0.067	0.094	0.197
	6	Yes	0.078	0.083	0.198
		No (Precalibrated)	0.059	0.065	0.153
	9	Yes	0.072	0.066	0.168
		No (Precalibrated)	0.056	0.051	0.131
	22	Yes	0.060	0.048	0.131
		No (Precalibrated)	0.059	0.056	0.140

Table 4. Positional accuracy results.

Figure 5. GCP measurements for positional accuracy estimation.

Figure 6. Differences between 1GCP–self-calibration orthoimage and 9GCP-precalibrated camera orthoimage measurements. It can be observed the displacement vectors between GCPs.

The results show the importance of following a rigorous scheme in all phases of the work. Especially in highly automated procedures that makes difficult the detection and correction of potential errors. In any case, it is advisable to use quality control techniques for the positional exactitude of the generated products (checkpoints measurement, ground distances, etc.).

References:

1. Leberl, F. (1991). The Promise of Softcopy Photogrammetry. In: Ebner, H., Fritsch, D. & Heipke, C. (eds). Digital Photogrammetric Systems, pp. 3-14. Kalrsruhe, Germany. Ed. Wichmann.
2. Phantom 3 Advanced – Show off your world in 2.7K – DJI. (n.d.). Retrieved May 20, 2017, from https://www.dji.com/phantom-3-advanced
3. Agisoft PhotoScan (n.d.). Retrieved May 20, 2017, from http://www.agisoft.com/
4. International Organization for Standarization (2013). ISO 19157:2013 Geographic Information – Data Quality. 146 p. Geneva, Switzerland.
5. Federal Geographic Data Committee. Geospatial Positioning Accuracy Standards. Part 3: National Standard for Spatial Data Accuracy. Reston, Virginia, USA.

mapKITE: A NEW CONCEPT FOR INFORMATION ACQUISITION IN ENVIRONMENTAL MAPPING PROJECTS

Delgado-García, Jorge [1], Colomina, Ismael[2], Molina, Pere[2], Blázquez, Marta[2]

[1] Dpto. Ingeniería Cartográfica, Geodésica y Fotogrametría, Universidad de Jaén, Campus de las Lagunillas, Edif. A-3. 23071 Jaén (Spain), Email:, jdelgado@ujaen.es
[2] Geonumerics, S.L., Avda. Carl Friedrich Gauss 11. 08860 Castelldefels (Spain), Email: ismael.colomina@geonumerics.com, pere.molina@geonumerics.com, marta.blazquez@geonumerics.com

Key-Words: UAS, Mobile Mapping System, Sensor Integration, Orientation and Calibration

ABSTRACT:

The new conception of environmental projects requires detailed information on the territory, such information that usually includes a temporal perspective that allows analysing the evolution of the phenomena over time. In recent years, the availability of different sensors that provide us this information is increasing every day, and now, the challenge is the integration of the data provided by them, aimed at having more information and the best quality. In this sense, in recent years the use of UAS, especially in projects in areas with a limited extent in which a high degree of detail is required, is an important element.

The use of this type of systems (UAS) is an important alternative to the use of conventional aerial mapping systems –manned systems- (considering surface to be covered and desired work scale) presents some aspects that need to be taken into account. First, the characteristics of these systems (payload, size, energy consumption, …) and their typical work scales imply that the lack of quality of their systems of orientation and positioning require the use of procedures based on ISO (indirect sensor orientation) that need an adequate network of ground control points (GCP) for the image orientation parameters estimation that compose the block. On the other hand, it is necessary to take into account that usually information captured using the aerial sensors must be combined with information captured by other terrestrial systems, so it is necessary to achieve an appropriate adjustment of the several layers of information provided by them.

These principles have guided the design of the mapKITE system which undoubtedly provides an innovative approach to information capture and has been developed through a European Union (EU) Horizon 2020 Programme under grant no. 64518 managed by the European GNSS Agency (GSA) [1]. The participants of mapKITE project are: GeoNumerics, Altais Cartografía y Urbanismo, CATUAV (Spain), DEIMOS Engenharia, UAVision (Portugal), EPFL (Switzerland), GRIDIT (Austria), TopScan (Germany), UNESP and ENGEMAP (Brazil). Actually, mapKITE is protected concept in terms of intellectual property rights under Spanish patent ES2394540 and US patent 14/417,435, and due patent applications have been already filed for Brazil and the EU.

Two basic elements are the bais of the mapKITE design. First, it is proposed a integrated scheme composed by an aerial subsystem (UAS) connected using a virtual tether to a terrestrial subsystem (MMS –mobile mapping system- that includes a precise GNSS/IMU system) (fig.1). And, on the other hand, and within its innovative scheme the use of kinematic ground control points, instead of conventional static ground control points.

Figure 1. mapKITE system

The vehicle that carries the MMS incorporates a coded target on the roof that receives terrain coordinates from the GNSS/INS system that integrates the MMS itself, so the target is referenced to a X,Y,Z,time coordinate system (cm-level accuracy). This target is visualized from the UAS and identified automatically (subpixel measurement) and it is used for the calculation of the trajectory (position and attitude of the UAS) (fig.2). Using this schema is possible to eliminate the use of conventional (static) ground control points, one of the most important problems previously mentioned for the use of UAS in mapping works. Additional information about the mapKITE concept can be obtained in [2], [3] and [4].

Recently, a thorough study of the accuracy of mapKITE mapping has been carried out, comparing its use with conventional procedures (static ground control points). The methodology and results in detail can be found in [5]. This campaign took place during June 2016, at the BCN Drone Center (Collsuspina, Spain). The test focused on mapping a short segment of a rural road around the BCN Drone Center. The mapKITE system was composed by a Spyro-4 quadcopter by UAVision (Portugal) and a Lynx MMS by Teledyne Optech operated by TopScan GmbH (Germany). The MMS includes a pair of laser scanners and a GNSS/INS navigation system (Applanix POS-LV420).

Figure 2. Kinematic ground control point (KGCP)

The flying height ranged between 80 and 90m above ground level (11% height variation of the mean height value), and the nominal forward overlap was 80% (base-to-height ratio of 0.156). The used camera was a Sony NEX-5R with a 20mm lens. A total of 149 images were recorded with an approximate GSD of 2 cm. A GNSS geodetic-grade triple-frequency receiver recording code and phase measurements, located at a reference point of known coordinates (mm-level accuracy) within the test area, was available.

A total of 37 control points were available in the area, 19 were used as ground control points (GCP) in the conventional image orientation schema and on the other hand, the mapKITE configuration is defined using 136 KGCP and just 4 GCP –located at the ends of the strips. In both cases, the rest of 17 control points not used in the conventional orientation are used as check point for positional accuracy estimation (fig.3).

The results show that mapKITE performs better than the conventional procedure in all respects: global systematic errors and dispersion (tab.1). The use of KGCP and a pair of GCPs at the beginning and end of the mission, better results than the conventional configuration with many more GCPs are obtained (fig.4).

An additional advantage of this system is that mapKITE provides an integral view of the territory, combining the information provided by aerial sensors (UAS) and terrestrial sensors (MMS) (fig.5).

The obtained results show the validity of the scheme, reaching levels of precision better than the traditional schemes based on the use of static ground control points, achieving a perfect fit between the information captured by the sensors installed in the aerial platform (point clouds obtained from the captured images using appropriate photogrammetric systems) and by the sensors installed in the terrestrial platform (point clouds directly by the terrestrial laser system –TLS-, although other configurations can be installed in function of the user's needs, for example, cameras in the visible range or other ranges - infrared, thermal, etc.-).

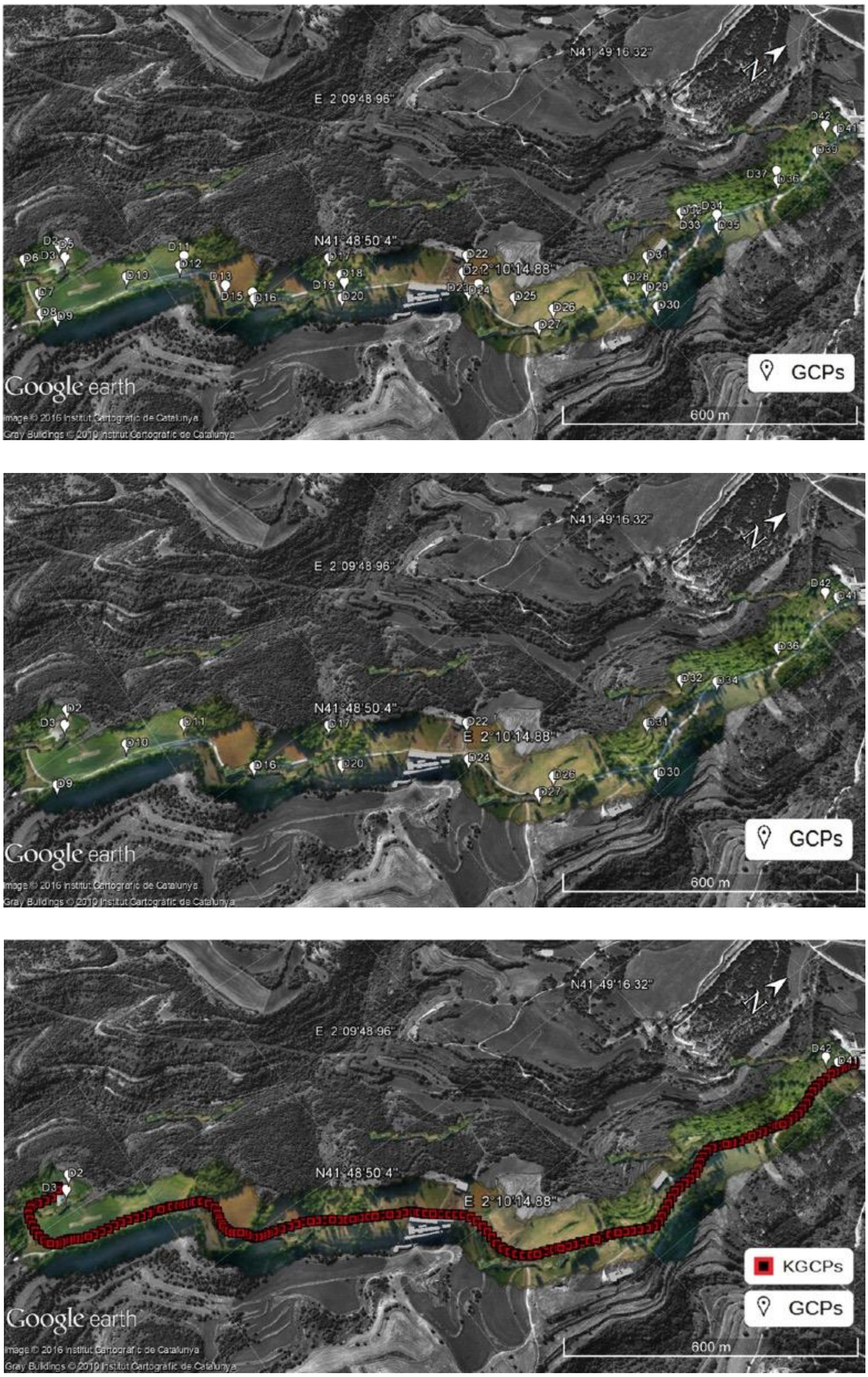


Figure 3. Top: Control points, bottom: Ground control points used in conventional mapping schema

Figure 4. Errors at check points. Top: conventional image orientation using GCPs, bottom: mapKITE schema using KGCPs and 4 GCPs

Statistic	Conventional orientation schema			mapKITE orientation schema		
	East(mm)	North(mm)	Height(mm)	East(mm)	North(mm)	Height(mm)
Mean	3	14	31	0	-5	7
Std Dev	49	48	87	32	36	86
Min	-59	-71	-103	-4	-64	-122
Max	164	110	245	103	76	212
RMS	49	50	92	32	36	87
RMS(px)	2.46	2.52	4.61	1.61	1.82	4.33

Table 1. Residual errors at check points

Figure 5. 3D point clouds. Top: obtained from UAS images, middle: captured with MMS, bottom: MapKITE schema that integrates aerial and terrestrial systems

References:

1. mapKITE (n.d.). Retrieved May 20, 2017, from http://mapkite.com/
2. Molina, P., Blázquez, M., Sastre, J., Colomina, I. (2016). mapKITE: a new paradigm for simultaneous aerial and terrestrial geodata acquisition and mapping. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, volume XLI-B1, pp. 957-962. 2016 XXIII ISPRS Congress, 12-19 July 2016, Prague, Czech Republic. doi: 10.5194/isprsarchives-XLI-B1,957-2016.
3. MapKITE: Total 3D mapping – Simultaneous aerial and terrestrial (2017). Retrieved May 20, 2017, from https://vimeo.com/181634599.
4. MapKITE: Presenting a new mapping paradigm to the world (2017). Retrieved May 20, 2017, from https://vimeo.com/214011604
5. Molina, P., Blázquez, M., Cucci, D.A., Colomina, I. (2017). First results of a tandem terrestrial-unmanned aerial mapKITE system with kinematic ground control points for corridor mapping. Remote Sensing, 9, 60, doi:10.3390/rs9010060.

THE EFFECT OF SPATIAL RESOLUTION OF UAS-BASED THERMAL IMAGERY ON TURBULENT HEAT FLUX ESTIMATES

Claire Brenner[(1)] , Matthias Bernhardt[(2)], Karsten Schulz [(3)]

[(1)] Institute of Water Management, Hydrology and Hydraulic Engineering, University of Natural Resources and Life Sciences, Vienna, Austria,
Phone + 43 1 47654 81615 , Email claire.brenner@boku.ac.at
[(2)] Institute of Water Management, Hydrology and Hydraulic Engineering, University of Natural Resources and Life Sciences, Vienna, Austria,
Phone + 43 1 47654 81608 , Email matthias.bernhardt@boku.ac.at
[(3)] Institute of Water Management, Hydrology and Hydraulic Engineering, University of Natural Resources and Life Sciences, Vienna, Austria,
Phone + 43 1 47654 81699 , Email karsten.schulz@boku.ac.at

Key-Words: Evapotranspiration, surface energy balance, two-source energy balance model, unmanned aerial vehicle, airborne remote sensing;

ABSTRACT:

Unmanned aerial systems (UAS) provide the means for analyzing spatial patterns of land surface properties and land surface-atmosphere exchange processes with high spatial and temporal detail as well as under all sky conditions. This is an advantage over spaceborne remote sensing, particularly in the case of thermal infrared imagery. Current operational satellite platforms offer a compromise between spatial and temporal resolutions and are limited to clear sky conditions.

In the present study, we use high-resolution thermal and optical imagery acquired with an octocopter UAS to estimate turbulent heat exchange at a grassland site. UAS data was collected during the ScaleX 2016 field campaign in Fendt, Germany. The site is part of the TERENO-prealpine observatory and is amongst others permanently equipped with an Eddy-Covariance (EC) system and a soil sensor network. The UAS-based thermal imagery has a ground resolution of around 5 cm. The optical imagery, with an even higher resolution, provides valuable information on vegetation properties as well as the fractional vegetation cover. A regular digital camera was modified in order to detect light also in the near-infrared spectrum, which allows a better discrimination of soil and vegetation components as well as vegetation density.

The land surface temperature (LST) information provided by the thermal imagery is the key input to a surface energy balance model that estimates the partitioning of available energy into latent and sensible heat fluxes. The Two-Source Energy Balance (TSEB) model [1] estimates sensible heat flux based on the air-to-surface temperature gradients as well as resistances against this flux and ultimately derives latent heat flux as the residual of the surface energy balance. The TSEB model is widely used for the assessment of turbulent heat fluxes over often large and heterogeneous areas [2]–[8]. In most applications, the driving land surface temperature information is derived from satellites.

This study aims at assessing the effect of the spatial resolution of land surface temperature information especially for the case of very high-resolution thermal imagery acquired with an UAS. For this purpose, we run the TSEB model with varying image resolution from the raw resolution up to aggregates that are close to satellite imagery resolution. In order to assess the performance of the model given the varying spatial resolution of the input data, flux estimates are compared to EC measurements. Account is taken of the footprint of the EC measurements, so that only modelled fluxes from within the footprint are considered in the comparison. Since we conducted UAV flights under varying conditions, e.g. different times of day, weather

and moisture conditions, the effect of spatial resolution under these varying conditions can be evaluated. Since EC measurements inherently represent an integral flux over the source area, we additional compare daily soil moisture variation at several points within the EC footprint to local latent heat flux estimates. This requires upscaling of instantaneous fluxes to daily fluxes, for which several reference quantities such as available energy, incoming shortwave radiation and reference evapotranspiration will be tested [9]–[11]. The comparison between daily fluxes and soil moisture reduction aims at assessing the plausibility of the emerging patterns in the spatially distributed flux estimates. Additionally we analyze if the basic assumptions that underlie the TSEB model are still valid given the fine discretization that the UAS-based thermal imagery makes possible.

References:

1. J. M. Norman, W. P. Kustas, and K. S. Humes (1995). “A two-source approach for estimating soil and vegetation energy fluxes in observations of directional radiometric surface temperature,” Agric. For. Meteorol., vol. 77, no. 3–4, pp. 263–293.
2. C. Cammalleri et al. (2012). “Applications of a remote sensing-based two-source energy balance algorithm for mapping surface fluxes without in situ air temperature observations,” Remote Sens. Environ., vol. 124, pp. 502–515.
3. M. Choi, W. P. Kustas, M. C. Anderson, R. G. Allen, F. Li, and J. H. Kjaersgaard (2009). “An intercomparison of three remote sensing-based surface energy balance algorithms over a corn and soybean production region (Iowa, U.S.) during SMACEX,” Agric. For. Meteorol., vol. 149, no. 12, pp. 2082–2097.
4. J. Cristóbal, A. Prakash, M. C. Anderson, W. P. Kustas, E. S. Euskirchen, and D. L. Kane (2016). “Estimation of surface energy fluxes in the Arctic tundra using the remote sensing thermal-based Two-Source Energy Balance model,” Hydrol. Earth Syst. Sci. Discuss., no. June, pp. 1–29.
5. R. Guzinski, H. Nieto, S. Stisen, and R. Fensholt (2015). “Inter-comparison of energy balance and hydrological models for land surface energy flux estimation over a whole river catchment,” Hydrol. Earth Syst. Sci. Discuss., vol. 19, pp. 2017– 2036.
6. W. P. Kustas et al. (2012). “Evaluating the two-source energy balance model using local thermal and surface flux observations in a strongly advective irrigated agricultural area,” Adv. Water Resour., vol. 50, pp. 120–133.
7. T. Xia et al. (2015), “Mapping evapotranspiration with high resolution aircraft imagery over vineyards using one and two source modeling schemes,” Hydrol. Earth Syst. Sci. Discuss., vol. 12, no. 11, pp. 11905–11957.
8. Y. Yang et al. (2016). “Daily Landsat-scale evapotranspiration estimation over a forested landscape in North Carolina, USA using multi-satellite data fusion,” Hydrol. Earth Syst. Sci. Discuss., no. June, pp. 1–45.
9. L. Xu and Q. Wang (2015). “Retrieval of Soil Water Content in Saline Soils from Emitted Thermal Infrared Spectra Using Partial Linear Squares Regression,” Remote Sens., vol. 7, no. 11, pp. 14646–14662.
10. C. Cammalleri, M. C. Anderson, and W. P. Kustas (2014). “Upscaling of evapotranspiration fluxes from instantaneous to daytime scales for thermal remote sensing applications,” Hydrol. Earth Syst. Sci., vol. 18, no. 5, pp. 1885–1894.
11. J. G. Alfieri, M. C. Anderson, W. P. Kustas, and C. Cammalleri (2017). “Effect of the revisit interval and temporal upscaling methods on the accuracy of remotely sensed evapotranspiration estimates,” Hydrol. Earth Syst. Sci., vol. 21, no. 1, pp. 83–98.

MULTI-SEASONAL MONITORING OF ACACIA LONGIFOLIA THROUGH UAS: POTENTIAL FOR DETECTION OF A BIOCONTROL AGENT

Nuno César de Sá [1] , Bruno Pato[2], Elizabete Marchante [1], Magno Guedes[2], Paula Castro[1], Raquel Caldeira [2], Ricardo Matos[2], Sabrina Carvalho [3], Hélia Marchante[4]

[1] University of Coimbra - Centre for Functional Ecology
[2] Introsys, SA. - Integration for Robotic Systems, R&D Division
[3] CoolFarm SA, Instituto Pedro Nunes
[4] Escola Superior Agrária de Coimbra

Key-Words: Unmanned Aerial Vehicles; Remote Sensing; Invasive Alien Plants; Biocontrol; Monitoring

ABSTRACT:

Invasive Alien Species (IAS) are responsible for an estimated 12 Billion euros per year in costs of controlling and repairing the ecosystems just in the European Union alone. Providing efficient and low cost solutions for monitoring is vital to ensure the success and sustainability of IAS management.

Acacia longifolia is one of the most widespread invasive plants in the Portuguese coast, characterized by rapid growth and prolific seed production. Recently, to assist in controlling A. longifolia spread, the Trichilogaster acaciaelongifoliae wasp was introduced and became the first biocontrol agent used for this purpose in Continental Europe. This agent is expected to disrupt the seed production by galling in the flowering buds.

Unmanned Aerial Systems (UAS) can provide an ideal low-cost, highly customizable solution for very high resolution mapping of invasive alien plants (IAP). UAS also provide very high resolution canopy height models and allow to extract/predict various structural parameters, thus providing previously unachievable data for management.

This research presents the first assessment of using UAS for A. longifolia detection throughout different seasons and also to determine vegetation characteristics such as height and crown parameters. It also provides information on how continuous monitoring of A. longifolia flowering can be used to monitor the establishment of T. acaciaelongifoliae.

To test the usability of UAS for monitoring A. longifolia, two areas with biocontrol and three without, with approximate 3.5 hectares were selected in the Portuguese coast. UAS data was acquired in the various seasons between 2017/2018 to test the detection of A. longifolia under different phenological states. We tested pixel and object-based classifications and report on the achievements of each approach.Using image processing techniques we extracted A. longifolia vegetation structure and compared these results with those from field measurements.

USING MULTITEMPORAL UAV IMAGERY TO ESTIMATE TREE HEIGHT GROWTH IN *PINUS PINEA* PLANTATIONS IN PORTUGAL

Juan Guerra Hernandez[1], Eduardo González Ferreiro[2], Paula Soares[3], Margarida Tomé[4], Vicente Monleón[5], Ramón Alberto Díaz Varela[6]

[1] Forest Research Centre (UID/AGR/00239/2013), School of Agriculture, University of Lisbon, Departamento de Recursos Naturais, Ambiente e Território Tapada da Ajuda, 1349-017 Lisboa, Portugal, juanguerra@isa.ulisboa.pt
[2] Sustainable Forest Management Unit (GI-1837-UXFS). Department of Agroforestry Engineering, University of Santiago de Compostela, Escuela Politécnica Superior, R/Benigno Ledo, Campus Universitario, 27002 Lugo, Spain. edu.g.ferreiro@gmail.com.
[3] Forest Research Centre (UID/AGR/00239/2013), School of Agriculture, University of Lisbon, Departamento de Recursos Naturais, Ambiente e Território Tapada da Ajuda, 1349-017 Lisboa, Portugal, paulasoares@isa.ulisboa.pt
[4] Forest Research Centre (UID/AGR/00239/2013), School of Agriculture, University of Lisbon, Departamento de Recursos Naturais, Ambiente e Território Tapada da Ajuda, 1349-017 Lisboa, Portugal, paulasoares@isa.ulisboa.pt
[5] Sustainable Forest Management Unit (GI-1837-UXFS). Department of Agroforestry Engineering, University of Santiago de Compostela, Escuela Politécnica Superior, R/Benigno Ledo, Campus Universitario, 27002 Lugo, Spain, vjmonleon@fs.fed.us.
[6] Sustainable Forest Management Unit (GI-1837-UXFS). Department of Agroforestry Engineering, University of Santiago de Compostela, Escuela Politécnica Superior, R/Benigno Ledo, Campus Universitario, 27002 Lugo, Spain, ramon.diaz@usc.es

Key-Words: Unmanned aerial systems (UAS); forest inventory; forest growth; canopy height model (CHM); object-based image analysis (OBIA), structure-from-motion (SfM).

ABSTRACT:

Recent advances in Structure from Motion (SfM) offer the possibility to collect multi-temporal canopy height models (CHM) at very high spatio-temporal scale to enhance individual-tree growth knowledge, by using low-cost grade cameras mounted in light Unmanned Aerial Vehicles (UAV). CHM has been widely used to assess diverse structural aspects of forests (e.g vertical and horizontal distribution, continuity and density, forest gaps, etc.). Some of these aspects are closely related with key parameters required in forest management (e.g. forest fire risk and disturbances, forest stocks, and forest growth, among others).

The aim of this this study is to estimate tree height growth derived from light UAV-based DAP (Digital Aerial Photogrammetry) under different fertirrigation treatments. To analyse it, we flew a Pinus pinea L. plantation under different sylvicultural treatments in Central Portugal (Fig. 1), by using a fixed-wing UAV in 2015 and 2017. The P. pinea plantation has a density of 63 stems ha-1 distributed in a 10 x 16 m grid. Six adjacent rectangular plots were established in the field and a complete randomized block design was implemented using 2 blocks and 3 treatments: control (T0) and two different levels of fertirrigation (T1 with with a rate of 76 kg N ha-1 yr-1, 15 kg P ha-1 yr-1 and 15 kg K ha-1 yr-1 and T2 with just twice the amount was used for T1). Further, a total of 139 mm in T1 and 278 mm in T2 of additional water were supplied during the growing season, at a constant daily rate of 0.92 and 1.85 mm of water for T1 and T2, respectively. A total of 290 trees were included within the study area (N = 96 for T0, N = 94 for T1 and N = 100 for T2).The study site is characterized by fairly flat terrain (slopes from 0 to 6%) and no understory.

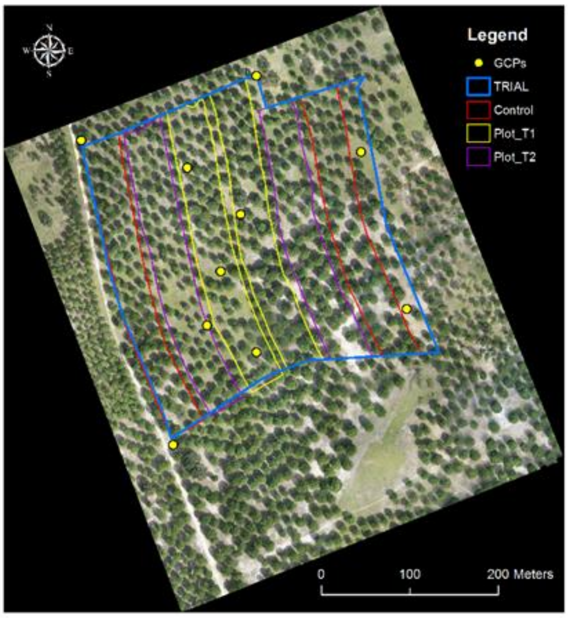


Figure 1.-UAV-RGB-Ortomosaic from the study area. Study site (blue line) with the locations of the different plots and treatments (red, yellow and magenta polygons) and ten ground control points (GCPs) (yellow dots)

The airborne campaigns were conducted by Terradrone Co., on March of 2015 and 2017 using the same sensor and flight parameters. Both campaigns used a RGB camera mounted on the fixed-wing UAV SenseFly eBee. The RGB camera was a Canon Powershot S110 with a 4000 × 3000 pixel detector capturing images at ISO 200 and 1/2000 seconds with a 5.320 mm focal length and sensor dimension of 7.4 x 5.58 mm. It provided ~6 cm pixel−1 resolution for an altitude of 170 m above ground level. The flight plan covered the entire study area with a lateral and longitudinal overlap of 80 and 75%, respectively. The flight line spacing was 48 m and each picture covered an area of 240 x 180 m. In the SfM image reconstruction process, a set of 190 (year 2015) and 202 images (year 2017) were used to generate each orthomosaic and Digital Surfaces Models (DSMs). The average ground sampling distance (GSD) values were 6.23 and 6.21 cm pixel-1, respectively.

The photogrammetric point clouds were processed using the stereomatching algorithm implemented in Pix4d Mapper Pro 3.1.22. Pix4d were also used to generate automatically the Digital Elevation Model (DEM) to obtain the CHMs in both years, and then an object based image analysis (OBIA) to perform an individual tree crown approach ITC delineation along the study area (n = 290 trees). Crown delineation results and tree tops positions and heights were then exported as vector polygons and points, respectively, in ESRITM shapefiles for subsequent analysis. The overall detection rate that was a 100%, with no false positives neither negatives.

Regarding, mean tree height growth between 2015 and 2017 from 290 trees was estimated at 0.45 m ± 0.13 m using UAV-based DAP along the study area. Taking into account the fertirrigation treatments we achieved 0.40 m ± 0.11 m in T0, 0.48 m ± 0.14 m in T1, 0.47 m ± 0.11 m in T2, respectively.

Our study offers insights into the expected precision of UAV-derived tree height growth in P. pinea plantation. The methodology used in this study could help to inform P. pinea forest and “montado/dehesa ecosystem” management, since the estimation of tree height growth from field data in this species is extremely difficult, attributable to the lack of strong apical dominance and umbrella-shaped crown. These results are a valuable contribution to the state of the art in sample plot forest inventory applications, especially now, when new low-cost tree attribute measurement techniques based on UAV data are being developed as a bridge between traditional RS and conventional calliper and hypsometer measurements.

Finally, the results indicate that information from light UAV-based DAP point clouds might generate spatially and temporally accurate inventories and have potential to support a number of sustainable forest management activities.

GENERATION OF CANOPY HEIGHT MODEL BASED ON POINT CLOUDS AND SPECTRAL DATA: A CASE STUDY ON GRAPEVINE

Mesas-Carrascosa, F.J.[(1)], **Peña, J.M.**[(2)], **de Castro A.I.** [(2)], **Torres-Sánchez, J.** [(2)], **Jiménez-Brenes, F.M.** [(2)], **García-Ferrer, A.** [(1)], **López-Granados, F.** [(2)]

[(1)] *University of Córdoba, Department of Graphic Engineering and Geomatics, Campus de Rabanales, 14071 Córdoba, Spain, fjmesas@uco.es*

[(2)] *Institute for Sustainable Agriculture, Crop Protection Department, CSIC, Spanish National Research Council, 14080-Córdoba, Spain.*

Key-Words: digital elevation model; classification cloud points; canopy height model; index color

ABSTRACT:

The availability of very high density cloud points is of increasing interest for scientists and other users involved in obtaining precise information for environmental, forestry or agronomical processes, among others. In the context of precision viticulture, UAV images are a potential way to map crop structure parameters, such as height row or vegetation cover fraction. To derive the structural information a very dense point cloud is extracted from UAV images (structure from motion). Every point contains X, Y and Z coordinates and spectral values of Red (R), Green (G) and Blue (B) bands from images can be assigned to the cloud points. Once cloud points are derived, they need to be processed and filtered to extract information of interest. Over the past years different filtering techniques have been developed to classify points from these cloud points. First, bare earth points are classified and a Digital Elevation Model (DEM) is generated. Then, the remaining points are classified as, for example, low, medium or high vegetation or buildings, producing a Digital Surface Model (DSM). The difference between a DSM and DEM yields a Canopy Height Model (CHM). Therefore, it is necessary to distinguish terrain points from the rest of typologies. To classify points as terrain most filtering techniques assume that the Earth's surface is continuous in all directions and apply geometric or morphological constraints. The methodology herein presented is based on the use of RGB spectral information associated with every point to discriminate between vegetation and other classes by colour indexes without using any geometric conditions. To validate the proposed methodology, cloud points from images taken with an RGB camera on-board an unmanned aerial vehicle (UAV) have been used. The UAV flights were performed at a vineyard whose land uses were grapevine rows, bare soil and cover crops (mainly composed by grass species) between the rows. The cloud points linked to this spectral information were accurately classified and a DEM, DSM and CHM were generated. These results are very useful to describe the structure of vineyards.

USING UNMANNED AERIAL VEHICLES TO DETECT FLOWERING OF AN INVASIVE TREE AS A PROXY TO ASSESS THE EFFICIENCY OF A BIOCONTROL AGENT

Nuno César de Sá[(1,2)*], Elizabete Marchante[(1)], Paula Castro[(1)], Sabrina Carvalho[(3)], Francisco A. López-Núñez[(1)], Hélia Marchante[(1,2)]

[(1)]Centre for Functoinal Ecology, Department of Life Sciences, University of Coimbra, Calçada martim de Freitas, 300-456 Coimbra, Portugal,
nuno.cesar.sa@gmail.com, emarchante@uc.pt, pcastro@ci.uc.pt, lnfran85@gmail.com*
[(2)] Escola superior Agrária, Instituto Politécnico de Coimbra, Bencanta, 3045-601 Coimbra, Portugal, hmarchante@esac.pt
[(3)] CoolFarm SA, Instituto Pedro Nunes, Rua Pedro Nunes Edifício C 3030-199 Coimbra, Portugal, sabrina@cool-farm.com

Key-Words: Unmanned Aerial Vehicles, Invasive Alien Plants, flowering detection, biocontrol

ABSTRACT:

Invasion by alien species is a worldwide phenomenon with negative consequences at both natural and production areas. Acacia longifolia is an invasive tree with a long track of economic and ecological impacts. The recent release of a biocontrol agent in Portugal, to prevent flowering of A. longifolia represents a major advance on the control of the species and demands a fast monitoring process to follow its establishment. We tested how Unmanned Aerial Vehicles (UAVs) Remote Sensing imagery can be used to detect and quantify flowering spatial distribution of A. longifolia (as a proxy to follow the biocontrol agent) in coastal habitats.

Images were acquired over seven areas including sand dunes and pine forests during the peak and off-peak flowering season. A binary classification using the Random Forest algorithm was applied to map spatial distribution of A. longifolia flowers. Additionally, the number of flowers produced was estimated in the field and correlated with UAV imagery aiming to remotely quantify the flowers. The flowering of A. longifolia was clearly detected by UAV sensors (Overall Accuracy > 0.96; Cohen's Kappa > 0.85) with the variations reflecting the habitat type and flowering season.

We found weak correlations (r2 ranging from 0.0134 to 0.156) between the field flowers abundance and those estimated by Remote Sensing. The variability of flowering intensity characteristic of this species, and the technical difficulties in linking the fieldwork measurement and the UAV sensor point of view which demonstrates the need to address this challenge in the future.

Our approach proved to be an effective and replicable way to detect flowering of A. longifolia. The biocontrol agent is expected to gradually diminish flowering which can now be accurately and timely detected by UAV imagery. This approach proved suitable to assess changes in ecological processes that alter plant morphology/ phenology over time.

CLIFF VEGETATION MONITORING USING CLOSE RANGE PHOTOGRAMMETRY AND UAS: TECHNICAL ISSUES AND PRACTICAL HINTS

Maurizio Buonanno(1), Giovanna Aronne(2), Sandro Strumia(3), Maria Danzi(4), Antonio Santo(5), Annalisa Santangelo(6)

(1) Institute for Agricultural and Forest Systems in the Mediterranean, Italian National Research Council (CNR-ISAFoM), via Patacca, 85, 80056, Ercolano, Italy – email: maurizio.buonanno@cnr.it
(2) Department of Agricultural Sciences, University of Naples "Federico II", Via Università, 100, 80055, Portici, Italy – email: aronne@unina.it
(3) Department of Environmental, Biological and Pharmaceutical Sciences and Technologies University of Campania "Luigi Vanvitelli" Via Vivaldi, 43 - 81100 Caserta, Italy – email: sandro.strumia@unicampania.it
(4) Geofotogrammetrica S.r.l, via Gemito Vincenzo Napoli, Italy – email: m.danzi@geofotogrammetrica.it
(5) Department of Civil, Architectural and Environmental Engineering, University of Naples "Federico II", via Claudio 21, 80125 Napoli, Italy – email: santo@unina.it
(6) Department of Biology, University of Naples "Federico II", Via Foria, 223, 80139, Napoli, Italy – email: annalisa.santangelo@unina.it

Key-Words: Cliff vegetation monitoring; UAS; SfM;

ABSTRACT:

Cliffs are steep slopes rocky formations, often vertical and sometimes overhanging. They are common on coasts, in mountainous areas, as walls of canyons and glacial valleys or along rivers and are usually formed by rocks that are resistant to erosion and weathering. Even if the total extension of cliff surfaces is not available because steep areas are not fully measurable from common maps, cliffs are widely distributed worldwide.

Although cliffs and rocky slopes are quite harsh habitats for plants to grow, they are characterized by a widespread phenomenon: the concentration of a number of endemic and rare plant species larger than in the surrounding flat areas [1] [2] [3].

Although so relevant for biodiversity conservation, studies on plant communities of the cliffs are sporadic, mainly because of site inaccessibility [2]. In such conditions conventional field sampling at the community level (e.g. permanent plots or transects) is challenging even for safety issues and sometimes personnel with rock climbing skills is required [4] [5].

To overcome the inaccessibility of such habitats, remote data collection by means of optical tools (i.e.binoculars, telescopes, telephoto lenses) is often used [6]. Goñi et al. [4] have developed two specific estimate methods to carry out censuses and population demography remote monitoring of rupicolous plant species. The first is based on plant individuals remote counts multiplied by an average Correction Factor (CF = real total number / distant total count); the second is based on scaled panoramic photographs, GIS analysis of total area of occupancy of vegetation patches and estimation of average individual density in a patch.

In addition to inaccessibility, verticality of cliff and steep rocky faces poses further problems. As highlighted by Goñi et al. [4] and Gigante et al. [7], the orthogonal projection of vertical surfaces used in conventional maps or orthomosaics brings some shortcomings, like the underestimation of the total area. To overtake such difficulties various attempts are reported.

In case of long-term monitoring, the Fixed Point Photography (FPP) or Photo Point Monitoring (PPM) technique was used [8]; it consists in taking multitemporal terrestrial photographs of a site, from a fixed point (x,y,z) and angle, using always the same lens focal length.

Moreover, an alternative approach based on oblique aerial photographs, derived from video imagery captured using an helicopter, was proposed by Barron et al. [5].

Within this scenario, the overall aim of our research was to test new protocols and technical solutions for long-term vegetation monitoring on inaccessible cliffs and rocky slopes, taking into account that they all must be realistically practicable in terms of time, staff involved and costs.

The herein described study represents a proof of concept showing how close range photogrammetry by means of Unmanned Aerial Systems (UAS), low-cost digital cameras and Structure from Motion (SfM) software can be used to derive high-resolution orthomosaics (orthoplanes) of vertical rocky faces to be used for vegetation and species long-term monitoring.

More specifically we report about the effects of various factors on image resolving power and in turn on the usability of such images for vegetation patch mapping and species recognition.

Our research was carried out in southern Italy coastal sites classifiable as the EU Habitat 1240 (Vegetated sea cliffs of the Mediterranean coasts with endemic Limonium spp.) and Habitat 8210 (Calcareous rocky slopes with chasmophytic vegetation). Some of the species of these two adiacent habitats are: Crithmum maritimum L., Limonium sp.pl., Limbarda crithmoides (L.) Dumort., Dianthus rupicola Biv., Primula palinuri Petagna, Eokochia saxicola (Guss.) Freitag and G. Kadereit. The time of the year for the aerial survey was choosen taking into account the phenology of the species to be mapped (e.g. flowering or leaf color phenology).

We used a DJI "Inspire 1" multicopter with a Zenmuse X3 gimbal camera with a small format Sony sensor (1/2.3" – 12Mpx) and a short focal length lens (f = 3.6 mm). The camera was setup in Auto Exposure mode and ISO 1600. The UAS was manually piloted to evenly spaced hovering points to ensure sufficient side and forward image overlap. Three sets of images were taken parallel to the cliff at about 40m, 20m and 5m; both the first and the second set covered the whole survey area. A fourth set of photos was taken at 20m with the optical axis of the camera no longer perpendicular to the cliff, but facing downwards at about 45° to reduce as much as possible "no-data holes" in the final 3D model and to catch plants growing in rock depressions.

Five USAF-1951 Resolving Power targets [9] ranging from group 0 to -5 were evenly distributed at the foot of the cliff to measure the effect of increasing distance on image quality and usability.

The entire data set (40m, 20m, 5m and oblique images) in JPEG format was orthorectified and mosaicked using Agisoft Photoscan, a well known SfM software. Then, the orthomosaics were input in a GIS software (QGIS v.2.18) for visual species identification and vector digitizing the perimeter of individual plants or vegetation patches. Moreover, unrectified images taken at each range were examined for resolution power and species recognition possibility.

To discuss the final resolving power of the optical system with and without carrier induced vibrations, we performed a second test in a simplified scenario using a SJCam "SJ6 Legend" action camera (1/2.3" - 16Mpx - f = 3 mm) mounted both on a tripod (terrestrial images) and on a WLToys V393 multicopter with vibration damping supports (aerial images). Two USAF-1951 targets were used to measure the final resolving power (RP) at 3m, 4m, 5m and up to 30m with a 5m step. Further, we tested the effect of using two different ISO settings (200 and 1600).

The main factor influencing the resolving power of the unrectified images was the camera-to-subject distance. Until 10 meters it was possible to map vegetation patch perimeter and area, but fine details were blurred and species recognition of small plants was not reliable. Species photointerpretation accuracy increased after using training photographs taken at higher resolution by means of a DSLR camera with a lens of medium focal length (e.g. f = 55 mm). Only at 5 meters from the subject (RP 0.177 lp/mm; min. bar width = 2.83mm) details were sufficient for species recognition without any aid.

Other factors of varying degree can influence the resolving power of unrectified images taken using a UAS. To reduce their negative effects we suggest: a) to ensure that the propellers are well balanced and the vibration dumpers are in good condition; b) to set the camera at low ISO values (e.g. 200); c) to prefer a camera with a 1" or possibly APS-C sensor and mounting a lens of relatively long focal length (e.g. f = 8.8; d) to avoid low light conditions.

Results showed that the resolution power of the images is further degraded by the treatment with the SfM software due to the difficulty of image matching over vegetated areas and to the resampling procedure needed for orthorectification. Image matching can be even more difficult when images are taken in windy conditions because crown and leaves position changes between overlapping images.

The overall results confirm that ground sampling distance (GSD) calculated on the base of sensor size, lens focal length and flying height above the terrain (i.e. camera-to-subject distance) is only a first guess of the dimension of the smallest object visible in the final orthomosaic.

After our trial surveys we can highlight some shortcomings of UAS cliff vegetation monitoring and suggest possible solutions.

The pilot loses the depth perception when the UAS is just a few tens of meters away from him. Consequently, it is unsafe to flight too close to the cliff face without a second observer nearby it or without some technical aids like First Person View (FPV) or obstacle avoidance sensors.

In case of manual UAS piloting, to obtain a full coverage of images with the needed forward and side overlap becomes increasingly difficult as the distance from the cliff decreases. A possible solution is to couple the close image data set (e.g. 5m) with another one at longer distance (about 15 meters), finally using both to create the photogrammetric model in the SfM software. If the morphology of the cliff face is not too complex, an automatic flight/shooting plan could be used, but at present only few "Mission Planning" software offer visual 3D planning functionality like the EPFL TOPO Planner [10]. A pre-determined flight plan is even more desirable in case of a multitemporal monitoring project.

Reducing the distance from the cliff, the camera field of view (FOV) decreases too, while the total number of images to be analysed in the SfM software increase. This will impact the analysis time and eventually require a more powerful computer hardware. Consequently, the distance should always been chosen in relation to the required task (i.e. community mapping or species recognition) with the aim to minimize the total number of images.

The area and perimeter of a given patch of vegetation can change in relation to the chosen orthoprojection plane. Consequently, in case of a long term vegetation monitoring project the position of such a plane must be described.

Finally we suggest involving at least two operators: a UAS pilot and a botanist. The latter will locate the areas to be surveyed and, with the help of an FPV system and a second radio control, will shoot photos of plants details and will support the pilot in maintaining a safe distance from the cliff.

For the next future we planned to explore the use of multispectral NIR sensors and semi-automated object-oriented image classification to improve cliff vegetation mapping.

References:

1. Davis P.H. (1951) Cliff Vegetation in the Eastern Mediterranean. J. of Ecology. 39 (1), 63-93.

2. Larson, D.W., Matthes, U., Kelly, P.E. (2008) Cliff Ecology: Pattern and Process in Cliff Ecosystems. University Press, Cambridge, UK.

3. Aronne G, De Micco V, Santangelo A, Santangelo N, Santo A, Buonanno M. (2014) Coastal Vertical Cliffs of the National Park of Cilento: Reservoirs of Endemic Species. In: Viccione G, Guarnaccia C, eds. Latest Trends in Engineering Mechanics, Structures, Engineering Geology, 77-85.

4. Goñi D., Garcia M.B., Guzman D. (2006) Métodos para el censo y seguimiento de plantas rupicolas amenazadas. Pirineos, 161:33-58.

5. Barron S.J., Delaney A., Perrin P.M., Martin J.R., O'Neill F.H. (2011). National survey and assessment of the conservation status of Irish sea cliffs. Irish Wildlife Manuals, No. 53. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.

6. Ercole S., Giacanelli V., Bacchetta G., Fenu G., Genovesi P. (ed.) (2016) Manuali per il monitoraggio di specie e habitat di interesse comunitario (Direttiva 92/43/CEE) in Italia: specie vegetali. ISPRA, Serie Manuali e linee guida, 140/2016.

7. Gigante D., Attorre F., Venanzoni R., Acosta A.T.R., Agrillo E., Aleffi M., Alessi N., Allegrezza M., Angelini P., Angiolini C., Assini S., Azzella M.M., Bagella S., Biondi E., Bolpagni R., Bonari G., Bracco F., S. Brullo, G.Buffa, E. Carli, G. Caruso, S. Casavecchia, L. Casella, B.E.L. Cerabolini, G. Ciaschetti, R. Copiz, M.Cutini, S. Del Vecchio, E. Del Vico, L. Di Martino, L. Facioni, G. Fanelli, B. Foggi, A.R. Frattaroli, D.Galdenzi, C. Gangale, R. Gasparri, Genovesi P., Gianguzzi L., Gironi F., Giusso Del Galdo G., GualminiM., Guarino R., Lasen C., Lastrucci L., Maneli F., Pasta S., Paura B., Perrino E.V., Petraglia A., Pirone G.,Poponessi S., Prisco I., Puglisi M., Ravera S., Sburlino G., Sciandrello S., Selvaggi A., Spada F.,Spampinato G., Strumia S., Tomaselli M., Tomaselli V., Uzunov D., Viciani D., Villani M., WagensommerR.P., Zitti S. (2016) A methodological protocol for Annex I Habitats monitoring: the contribution of Vegetation science. Plant Sociology, 53(2): 77-87.

8. JNCC (2004) Common Standards Monitoring Guidance for Maritime Cliff and Slope Habitats. Joint Nature Conservation Committee.

9. US Dept. of Defence (1959) Military Standard - Photographic Lenses (MIL-STD-150A). Section 5.1.1.7, Resolving Power Target, p.20.

10. Gandor F., Rehak M., Skaloud J. (2015) Photogrammetric mission planner for RPAS. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-1/W4, p. 61-65.

USE OF 3-D HYDROLOGIC MODELLING AND UAV-PHOTOGRAMMETRY TO CHARACTERIZE THE PHYTOEXTRACTION EFFICIENCY OF POPLAR TREES IN A CADMIUM CONTAMINATED AGRICULTURAL FIELD

Alessandra Capolupo(1), Paolo Nasta(1), Mario Palladino(1), Elena Cervelli(1), Lorenzo Boccia*(2), Nunzio Romano(1)

(1)Department of Agricultural Sciences (DIA), University of Naples Federico II, Via Università, 100 – 80055 Portici (NA) – Italy, alessandra.capolupo@unina.it, paolo.nasta@unina.it, mario.palladino@unina.it, elena.cervelli@unina.it, nunzio.romano@unina.it
(2)Department of Architecture (DIARC), University of Naples Federico II, Via Forno Vecchio, 36 - 80134 Naples – Italy, lorenzo.boccia@unina.it

Key-Words: UAV – photogrammetry; Cd contaminated areas; poplars phytoextraction efficiency

ABSTRACT:

The accumulation of non-essential heavy metals in agricultural soils and consequent environmental contamination raises concerns over their potential toxic effects on human health. Unfortunately, over the past years, the Campania Region (Southern Italy) has been subjected to illegal dumping of industrial or household waste. Particular attention is devoted toward the National Interest Priority Site (NIPS) Domitian Coast Flegreo and Agro Aversano because it is characterized by a patchy distribution of anthropogenic and geogenic pollutants. Contrary to other heavy metals, Cadmium (Cd) is of considerable environmental concern. Industrial and agricultural applications of cadmium include the production of batteries, alloys, and pigments and chemical fertilizer and pesticides[1]. Poplar is suitable to absorb and accumulate Cd in its roots and is usually used for phytoremediation of contaminated soils [1]. Nevertheless, direct determination of Cd in poplars roots is an expensive, time-consuming and destructive activity. To circumvent the drawbacks of conventional direct approach, scenario-based strategies obtained by using advanced hydrological modelling tools, like the HydroGeosphere (HGS) model, have been developed to examine both contaminants transport in groundwater and solute surficial distribution in a 3D environment. HGS model accuracy is strongly influenced by detailed information on surface topography, commonly described by a Digital Elevation Model (DEM). A high resolution DEM was generated by applying Unmanned Aerial Vehicles (UAVs) that allows to set the flight quotas by adapting the aerial photos resolution to the object under investigation, and to acquire images in flexible date [2]. All in all, UAVs reduce also time and costs in retrieving aerial data [2]. In the present work, the assessment of Cd removal made by phytoextraction of poplars is evaluated by combining the HGS model with a fine resolution DEM, generated by UAV – photogrammetry. To achieve this aim, two different scenarios have been compared: the former is characterized by bare soil (BS), while the latter considers poplar plantation (PP).

The study area is an experimental field of about 4,500 m2 located near the town of Trentola Ducenta. A total of 23 soil samples were collected on a regular grid of 25 x 25 m and subsequently tested in the laboratory according to the EPA 6010C 2007 protocol. Traces of Cd were detected overall the study area although its concentration is lower than the Italian legal limit of 2 mg kg−1 (T.U. Ambientale 156/06). Thehydraulic proprieties of the surface and the subsurface soil domains were determined in laboratory by using the evaporation method on undisturbed soil samples collected at three depths along a soil profile located in the experimental area. In order to generate the high-resolution DEM, a flight mission was carried out by using an hexacopter Tarot FY690s that was equipped with a Canon PowerShot S100, a light camera of 12.1 Megapixels, calibrated using Agisoft Lens software. The flight mission was performed in clear sky conditions at the altitude of 25 m at the beginning of March, before the plantation of the poplar trees. The period was

chosen when the field was not covered by vegetation, thus the DEM, is related only to the BS condition [3]. A topographic survey of ten proper made target, located on the field perimeters and plot center area, was also performed using DGPS Sokkia GRX1 in order to acquire Ground Control Points (GCPs) to be used during the aerial images orientation step. The aerial photos and GCPs were processed by applying Agisoft Photoscan Professional software in order to carry out a DEM of 3x3 cm [4]. The surface of the obtained DEM was discretized in 50 x 50 cm finite elements for the three-dimensional domain. Soil depth is set up 300 cm and the set of measured soil hydraulic parameters were associated to the three main soil layers. Subsequently, the HGS numerical simulations pertaining to BS, used as benchmark, and PP scenarios (PP scheme was set on a rectangular grid of 500 x 1000 cm) were run in order to understand the contribution of phytoextraction on Cd removal from the experimental area.

The beneficial effects of phytoextraction by poplar trees increase the removal of Cd by about 46% when compared to BS-scenario. In this way the roots absorption decreases the prospect to route Cd down the soil profile and up to the aquifer. Moreover, the results highlight the spatial re-distribution of Cd in both scenarios. The scenario-based approach coupled to high resolution DEM (3x3 cm) obtained by UAV - photogrammetry represents a promising technique for assessing the phytoextraction of heavy metals by reducing the operational costs and time.

References:

[1] Zacchini, M., Pietrini, F., Mugnozza, G. S., Iori, V., Pietrosanti, L., & Massacci, A. (2009). Metal tolerance, accumulation and translocation in poplar and willow clones treated with cadmium in hydroponics. Water, Air, and Soil Pollution, 197(1-4), 23-34.

[2] Nex, F., & Remondino, F. (2014). UAV for 3D mapping applications: a review. Appl. Geomat., 6 (1), 1–15 http://dx.doi.org/10.1007/S12518-013-0120-x

[3] Capolupo, A., Pindozzi, S., Okello, C., & Boccia, L. (2014). Indirect field technology for detecting areas object of illegal spills harmful to human health: application of drones, photogrammetry and hydrological models. Geospatial health, 8(3), 699-707.

[4] Capolupo, A., Pindozzi, S., Okello, C., Fiorentino, N., & Boccia, L. (2015). Photogrammetry for environmental monitoring: The use of drones and hydrological models for detection of soil contaminated by copper. Science of the Total Environment, 514, 298-306.

CHESTNUT HEALTH MONITORING BY AERIAL PHOTOGRAPHS OBTAINED BY UNNAMED AERIAL VEHICLE

Luís Miguel Martins[1] , João Paulo Castro[2], Ricardo Bento[3,4], Joaquim J. Sousa[3,4]

[1] Centre for the Research and Technology of Agro-Environmental and Biological Sciences, CITAB, University of Trás-os-Montes and Alto Douro, UTAD, Quinta de Prados, 5000-801 Vila Real, Portugal, lmartins@utad.pt.

[2] Centro de Investigação de Montanha, Instituto Politécnico, Bragança, jpmc@ipb.ptl

[3] University of Trás-os-Montes e Alto Douro, Engineering Department, 5000-801 Vila Real, Portugal, (rbento, jjsousa)@utad.pt

[4] INESC Technology and Science (INESC-TEC), 4200-465 Porto, Portugal

Key-Words: "*Cryphonectria parasitica*", "*Phytophthora cinnamomi*", "*Dryocosmus kuriphilus*" "Chestnut decline", "UAV", "eBee"

ABSTRACT:

The Chestnut ink disease caused by Phytophthora cinnamomi and the chestnut blight induced by Cryphonectria parasitica are the diseases that cause more damage to European chestnut (Castanea sativa).

After two decades from the first occurrence of chestnut blight in Portugal, the hypovirulence began to be observed in some locations. The population of these strains is characterized by low diversity. Many of the sub-populations belong only to theEU-11 group, which appears only in some orchards in Italy. Successful treatment depends on the way the population of the fungus extends into the area to be treated.

Recently (2014) a new important plague occurred in Portugal and in three years rapidly spread to important chestnut areas production. Dryocosmus kuriphilus is the insect responsible for the chestnut gall wasp and caused serious damages in Italian orchards. This is a serious concern for chestnut culture in Portugal due to its possible losses on fruit and timber production.

This study refers to the monitoring of chestnut decline, by aerophotogrammetric flights, covering 231 ha in the Padrela region (Valpaços). Unmanned Aerial Vehicle (UAV) eBee (Sensefly) was used and color and near infrared (NIR) aerial photographs were obtained. Those photographs were compared to aerial images taken in a national flight in 2006.

During the period between 2006-2014 new chestnut plantation occurred (11%), nevertheless the area covered by chestnut decreased. In 129 ha (56%) the chestnut decline increased. The biotic agents were the principal causes of the C. sativa decline, which was confirmed by field observations.

AUTOMATIC CHESTNUT TREES MONITORING BY AERIAL PHOTOGRAPHS OBTAINED BY UNNAMED AERIAL VEHICLE

Pedro Marques(1), Luís Pádua(1), Telmo Adão(1,2), Jonas Hruska(1), Joaquim. J. Sousa(1,2), Emanuel Peres(1,2), Luís M. Martins(1,3) and António Sousa(1,2)

(1) University of Trás-os-Montes e Alto Douro, Engineering Department, 5000-801 Vila Real, Portugal, al39126@utad.eu, luispadua@utad.pt, jonash@utad.pt
(2) INESC Technology and Science (INESC-TEC), 4200-465 Porto, Portugal, telmoadao@utad.pt, jjsousa@utad.pt, amrs@utad.pt, eperes@utad.pt
(3) Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB), 5000-801 Vila Real, Portugal, lmartins@utad.pt

Key-Words: Chestnut decline, chestnut ink disease, chestnut blight, UAV, time series analysis.

ABSTRACT:

The European chestnut (Castanea sativa), since 1980, assumed an important role in the Portuguese economy [1]. However, increased production led to the emergence of phytosanitary problems such as the chestnut ink disease (Phytophthora cinnamomi) and the chestnut blight (Cryphonectria parasitica). These diseases are one of the main causes of the decline of the chestnut tree, where, in Portugal resulted in a drastically reduction of the production area [2]. After two decades from the first occurrence of chestnut blight in Portugal, the hypovirulence began to be observed in various locations. Successful treatment depends on the way the population of the fungus extends into the area to be treated. In this way, it is necessary to have effective detection techniques necessary to monitor and mitigate the risk of occurrence of these problems, making cultivation of these crops a viable and sustainable business. To assess the presence of those problems, in the majority of the cases, direct ground observations have to be performed, which is a time-consuming and very laborious task. The symptoms caused by these diseases can be monitored using remote sensing platforms, through spectral signature or canopy analysis.

Unmanned Aerial Systems (UAS) are remote sensing platforms that can provide high-resolution images, obtained by different sensors with a notable versatility, ease of operation and cost-effective [3]. Making these platforms an attractive solution to areas where remote sensing information is needed [3], in which land monitoring is included. UAS-based data allows the processing of different types of information, as digital elevation models or orthoretified images where vegetation monitoring can benefit from the computation of these types of models. The possibility to survey considerable areas in quicker time, providing very-high spatial resolution images, makes UAS an ideal platform for monitoring areas with agriculture or forest plantations in diverse plant species [4], when compared with other remote sensing platforms as satellites and manned aircrafts [5]. Digital image processing techniques applied to the outputs derived from UAS images allows, among other, to determine the area occupied by vegetation on a given land parcel. This enables the identification of areas with higher production, allowing, for instance, sowing optimization, diseases and/or pest detection, promoting this way an efficient agroforestry management, in a single and multi-temporal perspective. The need for temporal vegetation cover monitoring is essential for the assessment of the chestnut's development, as well as their phytosanitary status, and to monitor new plantations. This way, the problem detection at an early stage becomes indispensable, allowing a quicker response and higher capacity to apply measures, saving up crops and reducing maintenance costs.

Therefore, the main objective of this study is to propose a methodology, based on image progressing techniques, to identify vegetation in aerial images taken by UAV over chestnut plantations. The orthoretified images along with the canopy surface models, will allow the monitoring of chestnut trees decline. The case

study is an area of 231 ha in the Padrela region (Valpaços, Portugal). A previous study of the same area was already performed and the results are presented in [1]. A fixed-wing UAV was used, in July 2014, and the obtained images were compared with aerial images of 2006. It was verified in 56% of the studied area that the growth was less than 5% or negative [1]. However, the analysis of the aerial images in this study were performed manually, which is a time-consuming task, and by selecting sampling areas. In the present study an automatic methodology to detect chestnut trees and to assess its development is proposed, in a UAV-based time-series analysis perspective. To collect the data a fixed-wing UAV was used, the eBee (senseFly SA, Lausanne, Switzerland). In the performed flights colour and near infrared (NIR) aerial photographs were obtained in two distinct years, 2014 and 2015. Comparing to Martins et al. [1] the proposed methodology allows to automatic obtain individual tree information (e.g. canopy area and height), making possible to assess the chestnut trees temporal development or decline and even to cover larger areas in a faster and effective way.

References:

1. L. Martins, J. P. Castro, R. Bento, and J. J. Sousa, 'Monitorização da condição fitossanitária do castanheiro por fotografia aérea obtida com aeronave não tripulada', Rev. Ciênc. Agrár. Soc. Ciênc. Agrár. Port., vol. 38, no. 2, pp. 184–190, 2015.
2. L. Martins, J. P. Castro, and E. Gouveia, 'Biological control of chestnut blight in Portugal', Acta Hortic., vol. 1043, pp. 51–56, 2014.
3. S. Getzin, K. Wiegand, and I. Schöning, 'Assessing biodiversity in forests using very high-resolution images and unmanned aerial vehicles', Methods Ecol. Evol., vol. 3, no. 2, pp. 397–404, Apr. 2012.
4. J. A. J. Berni, P. J. Zarco-Tejada, L. Suarez, and E. Fereres, 'Thermal and Narrowband Multispectral Remote Sensing for Vegetation Monitoring From an Unmanned Aerial Vehicle', IEEE Trans. Geosci. Remote Sens., vol. 47, no. 3, pp. 722–738, Mar. 2009.
5. A. Matese et al., 'Intercomparison of UAV, Aircraft and Satellite Remote Sensing Platforms for Precision Viticulture', Remote Sens., vol. 7, no. 3, pp. 2971–2990, Mar. 2015.

Aknowledgments:

This work was financed by the European Regional Development Fund (ERDF) through the Operational Programme for Competitiveness and Internationalisation - COMPETE 2020 under the PORTUGAL 2020 Partnership Agreement, and through the Portuguese National Innovation Agency (ANI) as a part of project "PARRA - Plataforma integrAda de monitoRização e avaliação da doença da flavescência douRada na vinhA" (Nº 3447) and ERDF and North 2020 – North Regional Operational Program, as part of project "INNOVINE&WINE – Vineyard and Wine Innovation Platform" (NORTE-01-0145-FEDER-000038).

VINEYARD DETECTION FROM THE COMBINATION OF RGB AND RED EDGE-BASED UAS IMAGERY

Luís Pádua[(1)], Telmo Adão[(1, 2)], Jonáš Hruška[(1)], Pedro Marques[(1)], Joaquim J. Sousa[(1, 2)], António Sousa[(1, 2)], Emanuel Peres[(1, 2)] and Raul Morais[(1, 2)]

[(1)] *University of Trás-os-Montes e Alto Douro, Engineering Department, 5000-801 Vila Real, Portugal, luispadua@utad.pt, jonash@utad.pt, al39126@utad.eu*
[(2)] *INESC Technology and Science (INESC-TEC), 4200-465 Porto, Portugal, telmoadao@utad.pt, jjsousa@utad.pt, amrs@utad.pt, eperes@utad.pt, rmorais@utad.pt*

Key-Words: vineyard segmentation; vegetation indices; aerial images; red edge imagery**.**

ABSTRACT:

The amount of information that can be extracted from Unmanned Aerial Systems (UAS) sensors enables different types of outputs such as orthorectified mosaics or digital elevation models, among others. Regarding vegetation remote sensing, a common task is to compute vegetation indices on the mosaics generated from unmanned aerial vehicles (UAVs) flights. Vegetation indices are a simple way to access crop parameters (e.g. leaf area index, vigour, yield, water status, nutritional requirements, disease presence, etc.) through the use of different sensors. Crop parameters obtained by vegetation indices computation can support better decision making of agriculture professionals resulting in a more efficient management of resources and yield maximization.

Regarding vineyards, automatic crop parameters identification based on image processing is particularly challenging. It usually involves the recognition of vine rows that can assume various formats/shapes from an aerial perspective (lines, curves and sinusoids) within a vineyard parcel, not always well-identifiable. To aggravate the problem, inter-vine row vegetation can be present, compromising, for example, the application of vegetation indices for discrimination purposes. Taking these issues into consideration, the application of typical image processing techniques is not effective, as presented in Figure 1. The results of the application of global and local thresholds to an image obtained from an UAV are compared with the proposed method. It is clearly noticeable the misleading detection of the vineyard vegetation by the usually used techniques.

To address the mentioned issues, in this study, data gathered from vineyards in Douro and Alto-Douro regions (Portugal) by a fixed-wing UAV equipped with RGB and red edge sensors was used. A two-step procedure combining vegetation indices and image processing techniques was applied to segment vineyard vegetation. Firstly, 26 vegetation indices using different band combinations (red edge, red, green and blue) were applied in different vineyard parcels, with different vine row orientations and shadow presence. The images obtained from applying each vegetation index were segmented and compared to manually segmented images to assess the accuracy for vineyard vegetation identification. The vegetation segmentation result of the proposed process is presented in Fig. 1. In the second part of this study, the vegetation indices with better performance, in the first step, were applied to exploit time series flights over vineyard parcels with the goal of characterizing the temporal evolution changes during the phonological development.

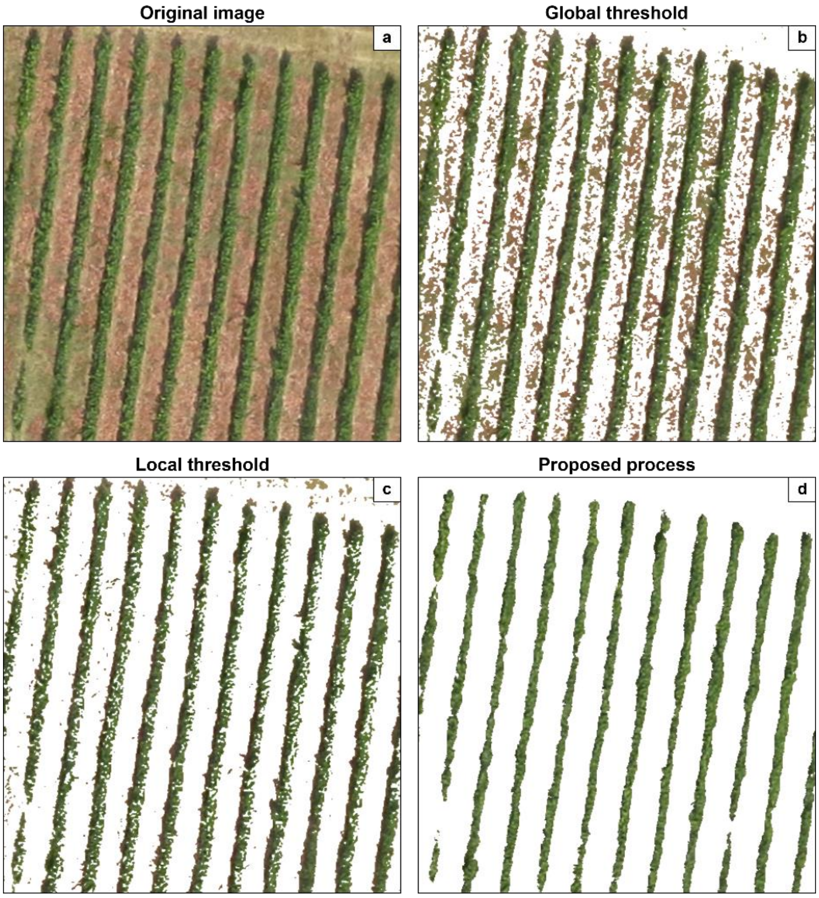


Figure 1. Vineyard vegetation segmentation from the application of traditional thresholding techniques (b) local thresholding, (c) global thresholding and with the (d) proposed process.

The obtained results demonstrated good accuracy on vineyard vegetation detection with the use of vegetation indices along with traditional segmentation techniques, when compared with manually segmented imagens. In a single image classification, depending on the used vegetation index, it reached 90% of exact vineyard vegetation segmentation. In all the tested image samples a minimum average of 80% was reached. When analysing a vineyard parcel with time-series UAV-based data, the vegetative development was noticeable along with its decline when close to the grape harvest season. However, outlier vegetation can also, in certain situations, be detected (e.g. grass, trees and small bushes), pointing out the need for developing more effective image segmentation techniques. The developed methodology is focused on vineyard detection but it can also be used as a first step to detect other types of vegetation present in an image.

Aknowledgments:

This work was financed by the European Regional Development Fund (ERDF) through the Operational Programme for Competitiveness and Internationalisation - COMPETE 2020 under the PORTUGAL 2020 Partnership Agreement, and through the Portuguese National Innovation Agency (ANI) as a part of project "PARRA - Plataforma integrAda de monitoRização e avaliação da doença da flavescência douRada na vinhA" (Nº 3447) and ERDF and North 2020 – North Regional Operational Program, as part of project "INNOVINE&WINE – Vineyard and Wine Innovation Platform" (NORTE-01-0145-FEDER-000038).

EVALUATION OF WINTER CROP DAMAGE USING UAV-BASED MULTISPECTRAL IMAGERY

Jełowicki Ł. (1) , Ostrowski W. (1), Sosnowicz K. (1)(2), Osińska-Skotak K. (1), Bakuła K. (1)

(1) *Warsaw University of Technology, Faculty of Geodesy and Cartography,*
Department of Photogrammetry, Remote Sensing and Spatial Information Systems, Warsaw, Poland
(2) *Skysnap Sp. z o.o., Warsaw, Poland*
lukasz.jelowicki@gmail, konrad.sosnowicz@gmail.com, (w.ostrowski, k.osinska-skotak, k.bakula)@gik.pw.edu.pl

Key-Words: damage detection; winter crop; UAV; multispectral imagery; image segmentation; vegetation indices; agricultural insurance

ABSTRACT:

The presentation is related to the exploitation of multispectral imagery from UAV in the assessment of damages after winter for rapeseed. Such damage is one of a few cases for which a reimbursement may be claimed in agricultural insurance. Since direct measurements are difficult in such a case, mainly because of large, unreachable areas, it is therefore important to be able to use remote sensing in the assessment of the plant surface affected by frost damage.

In the experiment, images were collected using a Sequoia multispectral camera registering in 4 spectral bands: green, red, red-edge, and near-infrared. Data was acquired from three altitudes above the ground, which resulted in different pixel sizes. That was the first part of the tests, as providing information about the impact of spatial resolution of imagery in detection of health crops undamaged by frost was expected.

Within several tests, various vegetation indices, calculated based on four spectral bands, were used (i.e. NDVI, GVI, SAVI, NDVI705, ratio of selected bands). Their values in the pixel-based approach were compared to measurements of training and test fields containing information about the number of health plants over a surface of 1 square metres. Such analysis allowed for describing the relation between the vegetation indices and the number of plants in a surface unit. In this approach, the best vegetation indices were selected in order to classify the areas qualified for reimbursement due to frost damage.

During the tests, the main problem, that needed to be addressed, was the occurrence of technical roads visible as tires traces, which should not be included in the calculation of the area uncovered by crops. It was the reason why the second approach related to the object image analysis was applied in the experiment. The orthomosaic of UAV multispectral images was segmented and classified into classes related to health crops, damaged crops, areas of ambiguous land cover and other uncovered areas (including technical roads).

The experiment presents the possibilities of using modern low-altitude photogrammetry from UAV using the multispectral sensor in application related to agriculture. Such equipment has been significantly miniaturized in recent years, and their current price nowadays allows for the commercialization of the presented method without significant financial efforts. This is observable in many applications, including the insurance sector.

UAS-BASED HYPERSPECTRAL SENSING METHODOLOGY FOR CONTINUOUS MONITORING AND EARLY DETECTION OF VINEYARD ANOMALIES

Telmo Adão(1), Emanuel Peres(1), Luís Pádua(2), Jonáš Hruška(2), Joaquim J. Sousa(1), Raul Morais(1)

(1) Department of Engineering, School of Sciences and Technology, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal; INESC-TEC (formerly INESC Porto), Porto, Portugal, telmoadao@utad.pt, eperes@utad.pt, jjsousa@utad.pt, rmorais@utad.pt
(2) Department of Engineering, School of Sciences and Technology, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal, luispadua@utad.pt, jonash@utad.pt

Key-Words: Remote sensing; Disease control; UAS; UAV; Hyperspectral sensors; Phytosanitary application management; Resources optimization; Sustainable agriculture.

ABSTRACT:

Viticulturists in general and, particularly, the ones of Douro Demarcated Region (Portugal) struggle for protecting their vineyards from diseases, plagues and other threats capable of putting at risk vine production and associated profit. Countermeasures mostly rely on the application of phytosanitary products in doses that usually do not fit the needs of targeting cultures. If insufficient quantities might lead to failure in cultures protection, excessive amounts, on the other hand, are likely to result in unnecessary financial losses as well as having impact in ecosystems due to, for example, environmental contamination and consequent biodiversity havoc. Thus, detecting such anomalies in its early stage, together with a more frequent monitoring will enable more sustainable agricultural practices. Emerging approaches towards that sustainability rely on remote sensing techniques carried out by Unmanned Aircraft Systems (UAS), which have already proven to be effective for monitoring vegetation and environmental parameters [1], mostly using RGB, thermal and multispectral images. Assessing crop condition is one of the most relevant tasks in this field and has been explored through, among others, for water status [2], vigour assessment [3] and biomass estimation [4]. However, the referred imagery is confined to a few bands in a tight part of the spectrum making them suitable in certain types of applications but useless when parameters out of their range are required for observation. Even multispectral sensors - which usually provide readings in a sparser spectral range than RGB or thermal alone – are confined to a low number of bands and discrete spectral nature (broad space between consecutive bands), leading to poor characterizations regarding the materials and components on a scene.

Recent technological developments boosted by alternative data acquisition techniques and components miniaturization enabled the integration of hyperspectral sensors in UAS - which until recent years were only being used in satellites [5] and manned aircraft (e.g. [6]) - opening new opportunities for cost-effective land surveys with high-spectral resolution. A larger use of the spectrum (it is common to find cameras operating in the 400-1000nm spectral range) and band narrowness (usually, hundreds of bands fulfil the spectral range considering small intervals between consecutive ones) sustain, from a technological viewpoint, hyperspectral’s potential for sensing more with higher detail and, consequently, with better profiling capabilities. Such developments triggered the development of several works exploring this type of imagery, including: biomass and nitrogen on wheat and barley [7][8], assessment of chlorophyll content and green biomass of pasture and barley crop [9], leaf-level measurements of chlorophyll fluorescence and Photochemical Reflectance Index (PRI) data on lemon orchards (water stress detection), verticillium wilt detection on olive cultures [10][11], chlorophyll densities estimation on rice paddies [12] and the exploitation of classified raster maps from biomass and nitrogen estimation to produce a work task for a precision fertilizer application on wheat. For vineyards, a few works based on UAS and hyperspectral were also proposed, more

specifically, leaf carotenoid content estimation [13], multitemporal analysis process of hydrological soil surface characteristics (H-SSC) [14] and relationship assessment of vegetation parameters (steady-state fluorescence and net photosynthesis) [15]. Despite the huge steps on high-resolution spectroscopy, at the best of our knowledge, the detection of specific diseases in vineyards remains poorly explored leaving a gap on the agriculture practices either on timely interventions to avoid/control plague spreading or on associated resources management. Thereby, contributions to guide the agriculture professional (e.g. farmer) in the application of the right resources - mainly but not only phytosanitary products - at the correct times and with the accurate balance between the vineyard parcels - providing care where it is most needed - are required and considered vital to fine-tune the traditional agricultural practices turning them into flawless processes for business activities oriented for profitability.

In addition, hyperspectral data processing progresses made in the last decades might have an important role to tackle with the lack of solutions for detecting vine diseases along with the availability of the sensors, mainly at post-flight stages where data needs to be interpreted in a meaningful way. To handle the referred data more efficiently, a dimension reduction task should be considered using, for example, Principal Component Analysis (PCA)-based methods [16]. Then, other operations can be carried out. One of them is known as target detection which refers to the assignment of a target or non-target label, based on spectral libraries [17]. Full target (for pixels of interest that are not contained by background) or subpixel target (mixed spectra with different endmembers) are the most common approaches. If operations involve classification, conditional density functions [18], support vector machines (SVM) and Markov-based techniques [19] are available approaches. In [20], different categories of classification were pointed out, including supervised and semi-supervised classification. To deal with the specificities of vegetation, others [13] suggested the use of chlorophyll indices. Additionally, software tools [21][22] and programming libraries [23][24] have been developed to hide the mathematical complexity behind those operations.

Thus, taking into account the key-knowledge that will extract relevant information from the collected hyperspectral data, the remainder of this article is dedicated to the proposal of a methodology that explores high-resolution UAS-based spectroscopy for vineyard diseases monitoring and early detection. The underlying processes rely in the following: (1) data acquisition, (2) pre-processing, (3) data computation (4) analysis and interpretation and (5) decision support for intervention. Acquisition refers to the flight campaigns carry out with UAS to gather data. UAV consists of a fixed-wing PrecisionHawk Lancaster with 60 minutes of flight autonomy capable of covering wide-range areas. Before take-off, flight has to be planned and uploaded to the drone for further guidance purposes, during the flight. Additionally, UAV is submitted to a setup involving several tests including self-diagnostics to wing flaps and ground control communication and, then, depending on the success of the tests, permission to launch is granted. It is noteworthy that the referred PrecisionHawk UAV requires a licensed operator with special training to perform launching. After take-off, UAV gains altitude and looks for the starting point of the planned flight trajectory to accomplish the specified mission under the control of its auto-pilot module. Along the way, a pushbroom hyperspectral sensor – Headwall's visible and near-infrared (VNIR) E-series device [25] – captures and stores high-resolution imagery in band sequential (BSQ) format as well as it gathers the respective coordinate points for geocoding purposes. When the mission is over UAV redirects itself for the landing position defined by the operator, which is recommended to be a soft and large enough surface for diminishing the probability of damage. Final step in acquisition consists in downloading gathered data for further utilization. Next, acquired data must undergo through a pre-processing step that usually consists in calibrating imagery in terms of radiometry, atmospheric noise, etc. as well as performing orthoretification - required when a pushbroom sensor is used - for spatial correction purposes. Atmospheric noise calibration is more common to be performed when satellite imagery is used, due to distortions inflicted by the several atmospheric layers that separate the sensor from the ground. However, foggy days might also require calibration for sensors on board of UAVs because of water particles-based distortion. This is a question to investigate during the course of the proposed project. Regarding radiometric corrections, most of the sensors would require it but, according to sensor's specifications [25], Headwall's VNIR seems to be free of that step since radio calibration files are already loaded onto the Nano VNIR for automatic calibration. Afterwards, data computation is responsible for pointing out the occurrence of diseases by comparing imagery data with spectral libraries. To properly handle spectral data, reduction methods should be applied, for example, wavelet compression and/or band selection [16]. This will be determined in the near future tasks of this project, which are: (1) gathering spectral readings of healthy and infected vineyard leafs; and (2) analysing spectral behaviour to choose a proper strategy for data handling. Spectral libraries should also result from the referred task. Continuing with data computation plan, after data reduction a matched filter for the detection of diseases (target detection) has to be applied. Manolakis [17] details the statistic processes behind target detection as well as strategies to achieve it (full and subpixels methods). Spectral Python [23] seems to be a promising programming tool which implements many of the referred methods. Its exploitation shall be carried out during the development of data computation process. Then, the resulting outcome is analysed and interpreted by an expert who can adjust some parameters (for example, perform correction on undetected areas with disease and deleting parts wrongly marked with infection) to correct farmer's guiding files (reports, task maps, etc.). Lastly, this validated data is delivered to the farmer who will be able to perform field interventions with a decision support provided by, for example: (1) heat maps properly subtitled to facilitate the identification of problems in a terrain parcel, from an aerial point of view; and (2) a set of instructions detailing the treatments. Sustainable agricultural practices through the proper administration of phytosanitary products are the main goal of this methodology. Although, other goals will be pursued: support decision for proper water irrigation (according to hydric stress) and fertilizer application (considering nitrogen concentrations). Finally, temporal data sets shall be considered for predicting production and fine-tune agricultural tasks in the different vineyard development stages. Fig. 1 depicts the referred methodology and the processes involved by it.

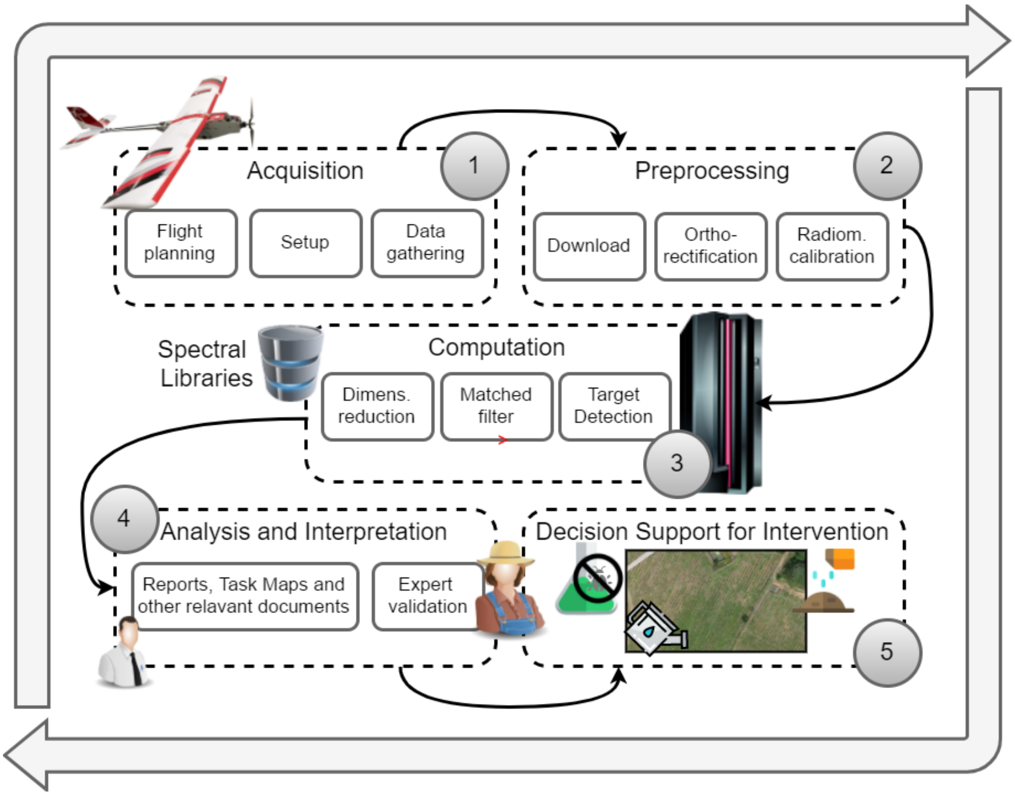


Figure 1. Methodology proposal for vineyard early disease detection and monitoring, from the acquisition process to the decision support.

Farmers devoted to winemaking professional activities are the main target-audience. This proposal intends to constitute the masterplan for the implementation of a system to ensure wine making process optimization focusing on vineyard crops early disease detection and monitoring, which will be developed in the context of two financed projects: INNOVINE&WINE – Vineyard and Wine Innovation Platform (NORTE-01-0145-FEDER-000038) and PARRA – "Plataforma integrAda de monitoRização e avaliação da doença da flavescência douRada na vinhA" (Nº 3447). European Regional Development Fund (ERDF) through the Operational Programme for Competitiveness and Internationalisation - COMPETE 2020 under the PORTUGAL 2020

Partnership Agreement, and through the Portuguese National Innovation Agency (ANI) supports PARRA project while INNOVINE&WINE project funds are provided by ERDF and North 2020 – North Regional Operational Program support.

References:

1. L. Pádua et al., “UAS, sensors, and data processing in agroforestry: a review towards practical applications,” Int. J. Remote Sens., vol. 38, no. 8–10, pp. 2349–2391, May 2017.
2. S. Park et al., “Estimation of crop water stress in a nectarine orchard using high-resolution imagery from unmanned aerial vehicle (UAV),” presented at the 21st International Congress on Modelling and Simulation, Gold Coast, Australia, 2015, pp. 1413–1419.
3. J. Primicerio et al., “A flexible unmanned aerial vehicle for precision agriculture,” Precis. Agric., vol. 13, no. 4, pp. 517–523, Aug. 2012.
4. J. Bendig et al., “Combining UAV-based plant height from crop surface models, visible, and near infrared vegetation indices for biomass monitoring in barley,” Int. J. Appl. Earth Obs. Geoinformation, vol. 39, pp. 79–87, Jul. 2015.
5. L. M. Dale et al., “Hyperspectral Imaging Applications in Agriculture and Agro-Food Product Quality and Safety Control: A Review,” Appl. Spectrosc. Rev., vol. 48, no. 2, pp. 142–159, Mar. 2013.
6. S. L. MacDonald, M. Staid, M. Staid, and M. L. Cooper, “Remote hyperspectral imaging of grapevine leafroll-associated virus 3 in cabernet sauvignon vineyards,” Comput. Electron. Agric., vol. 130, pp. 109–117, Nov. 2016.
7. I. Pölönen, H. Saari, J. Kaivosoja, E. Honkavaara, and L. Pesonen, “Hyperspectral imaging based biomass and nitrogen content estimations from light-weight UAV,” 2013, vol. 8887, p. 88870J–88870J–9.
8. E. Honkavaara et al., “Processing and Assessment of Spectrometric, Stereoscopic Imagery Collected Using a Lightweight UAV Spectral Camera for Precision Agriculture,” Remote Sens., vol. 5, no. 10, pp. 5006–5039, Oct. 2013.
9. A. Lucieer, Z. Malenovský, T. Veness, and L. Wallace, “HyperUAS-Imaging Spectroscopy from a Multirotor Unmanned Aircraft System: HyperUAS-Imaging Spectroscopy from a Multirotor Unmanned,” J. Field Robot., vol. 31, no. 4, pp. 571–590, Jul. 2014.
10. R. Calderón, J. A. Navas-Cortés, C. Lucena, and P. J. Zarco-Tejada, “High-resolution airborne hyperspectral and thermal imagery for early detection of Verticillium wilt of olive using fluorescence, temperature and narrow-band spectral indices,” Remote Sens. Environ., vol. 139, pp. 231–245, Dec. 2013.
11. R. Calderón, J. A. Navas-Cortés, and P. J. Zarco-Tejada, “Early Detection and Quantification of Verticillium Wilt in Olive Using Hyperspectral and Thermal Imagery over Large Areas,” Remote Sens., vol. 7, no. 5, pp. 5584–5610, May 2015.
12. K. Uto, H. Seki, G. Saito, and Y. Kosugi, “Characterization of Rice Paddies by a UAV-Mounted Miniature Hyperspectral Sensor System,” IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens., vol. 6, no. 2, pp. 851–860, Apr. 2013.
13. P. J. Zarco-Tejada, M. L. Guillén-Climent, R. Hernández-Clemente, A. Catalina, M. R. González, and P. Martín, “Estimating leaf carotenoid content in vineyards using high resolution hyperspectral imagery

acquired from an unmanned aerial vehicle (UAV),” Agric. For. Meteorol., vol. 171–172, pp. 281–294, Apr. 2013.

14. C. Corbane, F. Jacob, D. Raclot, J. Albergel, and P. Andrieux, “Multitemporal analysis of hydrological soil surface characteristics using aerial photos: A case study on a Mediterranean vineyard,” Int. J. Appl. Earth Obs. Geoinformation, vol. 18, pp. 356–367, Aug. 2012.
15. P. J. Zarco-Tejada, A. Catalina, M. R. González, and P. Martín, “Relationships between net photosynthesis and steady-state chlorophyll fluorescence retrieved from airborne hyperspectral imagery,” Remote Sens. Environ., vol. 136, pp. 247–258, Sep. 2013.
16. J. Burger and A. Gowen, “Data handling in hyperspectral image analysis,” Chemom. Intell. Lab. Syst., vol. 108, no. 1, pp. 13–22, Aug. 2011.
17. D. Manolakis and G. Shaw, “Detection algorithms for hyperspectral imaging applications,” IEEE Signal Process. Mag., vol. 19, no. 1, pp. 29–43, Jan. 2002.
18. J. A. Richards and X. Jia, Remote Sensing Digital Image Analysis: An Introduction. New York: Springer, 1990.
19. A. Plaza et al., “Recent advances in techniques for hyperspectral image processing,” Remote Sens. Environ., vol. 113, Supplement 1, pp. S110–S122, Sep. 2009.
20. J. M. Bioucas-Dias, A. Plaza, G. Camps-Valls, P. Scheunders, N. Nasrabadi, and J. Chanussot, “Hyperspectral Remote Sensing Data Analysis and Future Challenges,” IEEE Geosci. Remote Sens. Mag., vol. 1, no. 2, pp. 6–36, Jun. 2013.
21. Hexagon Geospatial, “ERDAS IMAGINE® 2016 PRODUCT FEATURES AND COMPARISONS.”.
22. Harris Geospatial, “ENVI Software Platform.” [Online]. Available: http://www.harrisgeospatial.com/. [Accessed: 29-Mar-2017].
23. “Welcome to Spectral Python (SPy) — Spectral Python 0.18 documentation.” [Online]. Available: http://www.spectralpython.net/. [Accessed: 29-Mar-2017].
24. S. Rosario-Torres, E. Arzuaga-Cruz, M. Velez-Reyes, and L. O. Jimenez-Rodriguez, “An update on the MATLAB hyperspectral image analysis toolbox,” in Defense and Security, 2005, pp. 743–752.
25. Headwall Photonics, “VNIR.” [Online]. Available: http://www.headwallphotonics.com/spectral-imaging/hyperspectral/vnir. [Accessed: 19-May-2017].

HYDRONES: A NEW SERVICE FOR MONITORING WATER BODIES, APPLICATION TO THE OBSERVATION OF A TIDAL BORE IN THE GARONNE RIVER

Jean-Christophe Poisson[(1)], Guillaume Valladeau[(1)], Pierre Prandi[(1)], Olivier Lauret[(1)]

(1) CLS, Toulouse, France, jpoisson@cls.fr

Key-Words: UAV, Hydrology, Precise altimetry, Tidal bore, Monitoring

ABSTRACT:

HyDrones (https://hydrones.cls.fr) is a new service which relies on the complementarity between flying UAVs and autonomous payloads, aiming to monitor continental water bodies, estuaries and coastal zones. Taking the advantage of UAV versatility and fast deployment capabilities, the solution is based on an innovative instrument capable of performing high resolution and real-time measurements of hydrological areas. Moreover, the HyDrones solution was designed to provide a cost-effective solution that can be easily and rapidly deployed on the end-users' areas of interest. Thus, on-demand fast data acquisition is possible, as well as offline long-term monitoring. The first version of the HyDrones instrument (the Mark1 prototype) is a lightweight altimeter providing precise water surface height. Currently, the instrument is being upgraded in order to provide other water metrics such as bathymetry, surface extent or freshwater quality.

In this study, we detail the results of an experimentation that took place on October 18th and 19th near Bordeaux (South of France). High tidal waves in the Bay of Biscay generated a tidal bore propagating upstream in the Garonne and Dordogne rivers. A joint experiment between Bordeaux University, La Rochelle University and the GET lab in Toulouse was set in Podensac, aiming to measure water heights through different techniques. HyDrones joined the experiment and performed the first flight of the HyDrones Mark1 prototype. Several instruments were set on site: a GNSS buoy, bottom pressure sensors, UAV photogrammetry and GNSS reflectometry. Inter-comparisons between instruments provide a great opportunity to assess the performance of the different techniques, and reveals that the HyDrones Mark1 prototype is able to collect valuable high-quality data.

ADVANCED REFRACTION CORRECTION FOR UAV-SFM MODELS OF RIVERS: A CASE STUDY FROM THE RIO PALANCIA, SPAIN

Carlos A. Puig-Mengual[1]; Francisco Martínez-Capel[1]; Amy S. Woodget[2]; Rafael Muñoz-Mas[1]

[(1)]Institut d'Investigació per a la Gestió Integrada de Zones Costaneres (IGIC), Universitat Politècnica de València (UPV), C/ Paranimf 1, 46730 Grau de Gandia, Valencia, Spain.
[(2)]Institute of Science and Environment, University of Worcester, Henwick Grove, Worcester WR2 6AJ, UK

Key-Words: Remote Sensing, UAV, Refraction Correction, River, Structure from Motion (SfM)

ABSTRACT:

The application of new technologies in fields such as land survey and ecology is providing frequent improvements and advances in data collection instruments and techniques, as well as tools used for data processing. Unmanned aerial vehicles (UAVs) combined with structure from motion photogrammetry (SfM) techniques represent an effective alternative to classical topographical surveys in some environments. In this study, we flew a UAV over a 100m reach of the Palancia River in Viver (Castellón, Spain) to collect high resolution video imagery. Three-dimensional reconstruction of the river channel was possible using SfM and allowed us to create an orthophoto, digital elevation model and point cloud. A set of ground control points (GCPs) were also measured in the field, using a dGPS. These GCPs appear in the imagery and make up the field control necessary for georeferencing and scaling the SfM outputs.

One of the problems of trying to model river bathymetry is the presence of water, which causes errors in the position of submerged points due to refraction. Our research aims to understand the magnitude of these errors and develop a new and effective refraction correction model. Our proposed model considers the geometry between the position of each UAV image and the submerged river channel, as represented by the 3D point cloud. Within this paper, we explain the theory of our model and apply it to the data collected from the Palancia River. We assess the success of our model in two ways: (1) by comparison with existing simple refraction correction methods (i.e. as presented by Woodget et al., 2015), and (2) by comparison with the 'true' position of the channel bed, as established using a UAV-SfM approach on the same river bed during a period of no flow.

COMBINING UAV PHOTOGRAMMETRY AND OPEN SOURCE SOFTWARE FOR FAST AND EFFECTIVE ASSESSMENT OF COASTAL EROSION – THE CASE STUDY OF SOUTH COVA DA GALA'S BEACH, PORTUGAL

Gil Gonçalves[(1)] , Marco Cunha[(2)], João Duarte[(3)]

[(1)] Dep. of Mathematics, University of Coimbra and INESC-Coimbra (Portugal), gil@mat.uc.pt
[(2)] GeoSurveys – Consultores em Geofísica, Lda (Angola), marcoaureliocunha@gmail.com
[(3)] IQGeo – Serviços, Lda. and Centro de Geociências, University of Coimbra (Portugal), joao.aduarte@iqgeo.pt

Key-Words: Portugal; Cova da Gala's beach; coastal erosion; UAV Photogrammetry; Open-source software

ABSTRACT:

Cova da Gala's beach is located South from Mondego river mouth, with jetties and groins around. Further adding that the sediment inflow, as well as the main current direction, is approximately North-South, a sedimentation on the North side of those artificial barriers and erosion on the South side are evident. In this paper, two UAV (Unmanned Aerial Vehicle) missions (February 12th, 2015 and April 4th, 2015) were carried out with the purpose of evaluate close range aerial photogrammetry as a fast and effective low cost methodology for rapid assessment, mapping and quantification of this coastal erosion. Moreover, the efficiency of a processing workflow using just free or open source software is also evaluated. Figure 1 shows the analysis of the height difference for the two DEMs generated for each UAV mission. It is noticeable the eroded areas and where deposition occurred. The results show that this methodology allows fast identification of areas with high topography change, either for erosion or deposition. Although other topographic changes might occur due to vegetation growth or Man practices, Cova da Gala's beach shows the high vulnerability of its dunes area with a very high rate of erosion and sediment outflow in just two months.

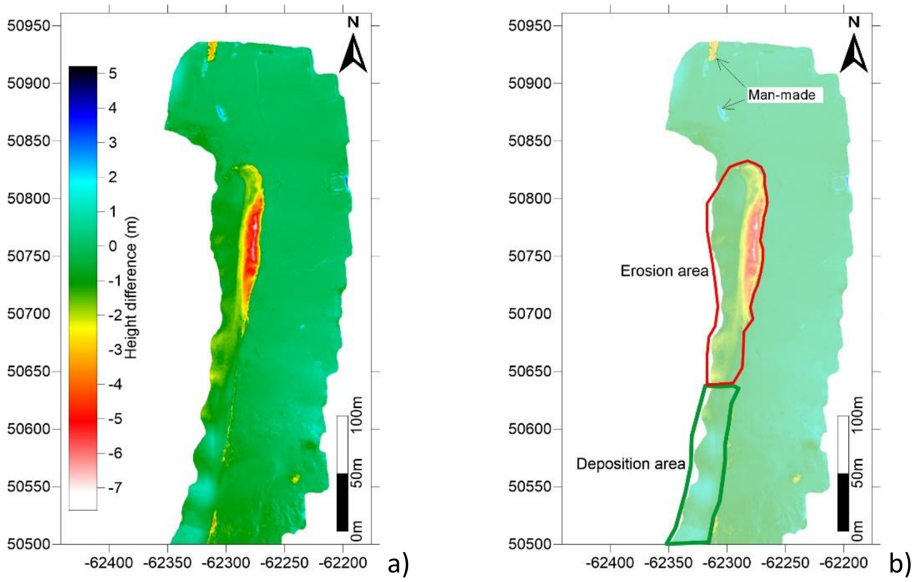


Figure 1. a) Height difference between DEMs; b) Manual interpretation of this difference

RPAS AS A NEW TOOL FOR THE STUDY OF SAND DUNES IN COASTAL ENVIRONMENTS: A CASE STUDY IN THE SOUTH ATLANTIC AREA OF SPAIN

Barbero, L.(1) , García-López, S.(2), López-Ramírez, J, A., (3) Muñoz, J, J., (4)

(1) Dpt. Ciencias de la Tierra, Universidad de Cádiz, 11510 Puerto Real, Spain, luis.barbero@uca.es
(2) Dpt. Ciencias de la Tierra, Universidad de Cádiz, 11510 Puerto Real, Spain, santiago.garcia@uca.es
(3) Dpt. Tecnología del Medio Ambiente, Universidad de Cádiz, 11510 Puerto Real, Spain, juanantonio.lopez@uca.es
(4) Dpt. Física Aplicada, Universidad de Cádiz, 11510 Puerto Real, Spain, juanjose.munoz@uca.es

Key-Words: structure from motion; low visual content; coastal geomorphology.

ABSTRACT:

In the south Atlantic coast of Cádiz (Spain), transgressive dunes are present in several places. These dunes represent special cases and are characterised by the dominance of sand transport over other processes, the dunes being not vegetated and highly mobile. Dune behaviour is strongly dependent on several factors: intensity, persistence and direction of prevailing winds, humidity, availability of sand, distribution and type of vegetation, anthropic actions, etc. Various methodologies have been used to study the dynamics of mobile dunes, these including aerial photography, traditional photogrammetry and mapping, luminescence, remote-sensing, and topographic mapping and GPS. All these methods have been used to quantify the volume of sand that is moved and the migration rates, but in most cases, they do not provide information on geometry changes in relation to weather variables.

The rise of small-low cost remotely piloted aerial systems (RPAS) together with the development of new methods of photogrammetry based in Structure from Motion (SfM) makes these new technologies a powerful new tool for studying and monitoring coastal sand dunes, which, in the case of the south Atlantic coast of Spain, result in several problems to the local population (road access problems, properties loss, vegetation coverage, etc.). Nevertheless, in the case of sand-dunes, the generally low visual content of the images makes the applications of this new approach challenging. In this work, we explore the main problems found when generating dense 3D point clouds using aerial images taken form RPAS and SfM software-based procedures in sand dunes and propose low time and cost consuming techniques. Our goal is to develop a low-time consuming method using RPAs to monitor changes in this highly dynamic scenarios.

SfM is based in highly redundant bundle adjustment based in the recognition of well-defined features in multiple overlapping images. So, increasing the overlap in the data set seems to be the obvious solution when the 3D model shows regions with poor resolution. In our case study at Valdevaqueros dune, we have increased the forward overlap until 90%, the side overlap being 70%. We also performed a double grid survey with grids perpendicular one to each other. Even with this high degree of image redundancy, the 3D reconstruction still fails in areas with very low visual content, that is, in areas where the sand is extremely clean and well sorted. Areas with vegetation, or remains of wood structures used for dune stabilisation produce a high quality dense 3D cloud with no problem.

In order to increase the visual content, we have tried the following methods: (1) The acquisition of low elevation photographs using different angles; (2) An artificial increasing of the visual contents of highly clean sand areas by the rapid deployment of coloured fishing nets that do not disturb the morphology; (3) The positioning of a dense net of ground control points in the areas of low visual content.

UAS AS TOOLS FOR RAPID DETECTION OF STORM-INDUCED MORPHODYNAMIC CHANGES AT SANCTI PETRI SPIT, SW SPAIN

L. Talavera[(1)] , L. Del Río[(1)], J. Benavente[(1)], L. Barbero[(1)], J. A. López-Ramírez[(2)]

[(1)] Earth Sciences Department, Faculty of Marine and Environmental Sciences, University of Cádiz, Av. República Saharahui 11519, Puerto Real, Spain. lara.talavera@uca.es, laura.delrio@uca.es, javier.benavente@uca.es, luis.barbero@uca.es
[(2)] Environmental Engineering Department, Faculty of Marine and Environmental Sciences, University of Cádiz, Av. República Saharahui 11519, Puerto Real, Spain. juanantonio.lopez@uca.es

Key-Words: Drones; Structure from Motion; DEM; coastal geomorphology; coastal monitoring; coastal erosion; overwash

ABSTRACT:

UAS-based (Unmanned Aerial Systems) methodologies have become the ultimate major tool for scientists of many fields, managers and engineers to monitor changing landscapes in a wide variety of spatial and temporal scales. Coastal geomorphology can undoubtedly take advantage of this enormous potential. The coastal zone is one of the most dynamic landscapes existing on earth, where continental and marine processes of different nature interact and shape the coastlines. These areas also sustain a progressively increasing percentage of population and economic activities, and are particularly prone to impacts related to climate change, which gives an idea of the importance and need of appropriate monitoring tools in these environments. It has already been proved that UAS fill the gap in the remote sensing techniques currently being applied in coastal monitoring studies [1, 3, 4], such as aerial photogrammetry, satellite imagery or LiDAR, among others, in which temporal and spatial scales, precision, and associated costs are sometimes inadequate.

This work tests the applicability of UAS-based data in assessing storm-induced morphodynamic changes at Camposoto beach, a small sector of Sancti Petri sand spit; the area is a mesotidal, low-energy environment located in the Bay of Cádiz Natural Park (SW Spain) that comprises multiple ecosystems such as sandy beaches, dunes and saltmarshes. The increased frequency and intensity of storms and the decreased longshore drift sediment supply of the last decades, together with the presence of human infrastructures, are causing the retreat of the whole system [2]., which is characterised by the frequent presence of dune escarpments and washover deposits (Fig. 1) that are re-activated even with modal storms. For evaluating storm-induced changes, two aerial surveys at 120 m height and a flight speed of 5 m/s were planned in the area before and after the occurrence of a relatively common storm (63 hours duration with a maximum wave height of 2.6 m) coinciding with a spring tide of 3.12 m height above datum. The missions were executed with an Atyges FV-8 octocopter mounted with a 24 Mpx Sony Alpha 7 full frame sensor RGB camera with a 28 mm focal length. The front and side overlap between images were set to 85-70% respectively for the first survey, and 85-75% for the second, due to the existing differences in wind conditions. Images acquired in both flights achieved a GSD (Ground Sampling Distance) of approximately 2.5 cm per pixel. For the first flight, a set of 33 GCPs (Ground Control Points) evenly distributed in the area was deployed and measured with a Leica RTK DGPS, while for the second flight 37 GCPs were used. The processing of the images and subsequent orthomosaics and DEMs (Digital Elevation Model) reconstructions were performed using Pix4D software. This methodology provided pre- and post-storm DEMs exhibiting RMS Vertical Errors of 6.89 and 5.54 cm, respectively. However, poor reconstruction of the point clouds was found at the seaward part of the models, the reason being attributed to the low texture and visual content of the sand in this flat area, as well as the presence of water.

Insights regarding storm-induced gain and loss of sediment over the study site could be identified in the DEMs using ArcGIS software. The landward migration of the beachface and the dune scarping at the mouth of the already existing washover channels were clear erosion signs. Accretion processes occurred in both the washover channels and back-dune deposits (Fig. 2). Hence, this study demonstrates not only the remarkable utility of UAS in accurately monitoring the different responses of beach and dune morphologies to storm events at the study area, but also their usefulness in acquiring data for numerical model calibrations. To sum up, this work contributes to confirm the suitability of UAS technology to satisfy the demands and needs in coastal monitoring studies.

Figure 1. a) and b) Dune escarpments at the mouth of the washover fan. c) Aerial photograph showing the back-dune washover deposit filling the artificial water channel at Camposoto beach.

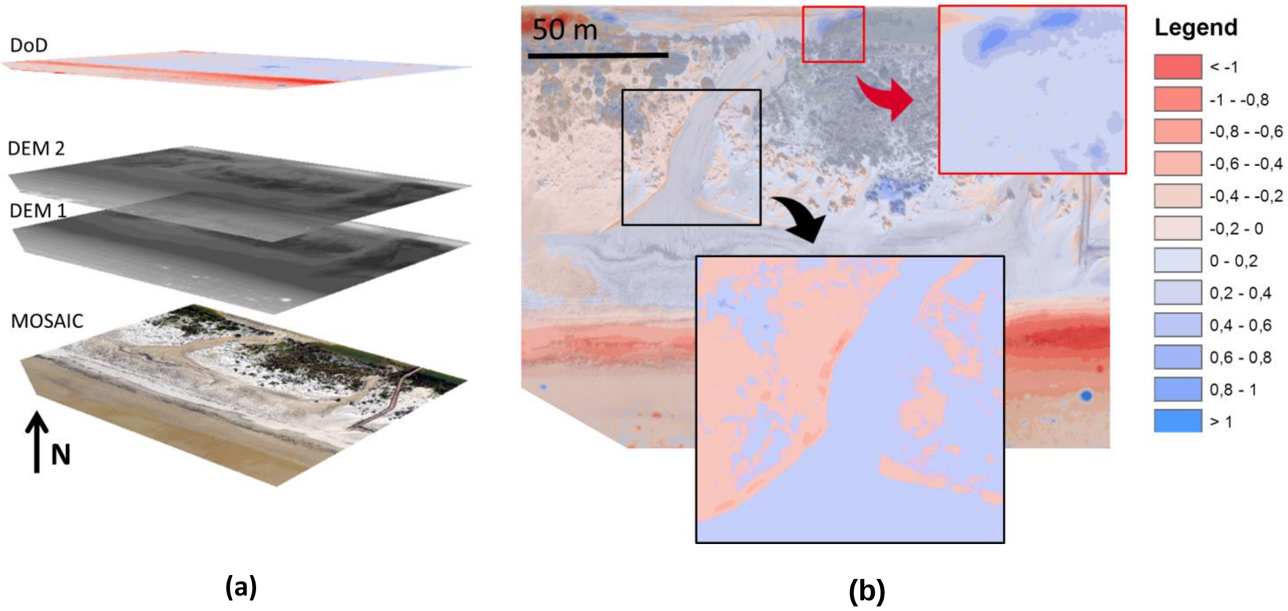


Figure 2. a) Mosaic, pre- and post- storm DEMs and the DoD (DEM of Difference) in ascending order. b) DoD exhibing erosion processes at the beach face and dunes located at the washover mouth (red), and accretion processes along the washover channel and at the lateral back-dune deposit (blue).

References:

1. Casella, E., Rovere, A., Pedroncini, A., Mucerino, L., Casella, M., Cusati, L.A., Vacchi, M., Ferrari, M. & Firpo, M. (2014): Study of wave run-up using numerical models and low-altitude aerial photogrammetry: A tool for coastal management. *Estuar Coast Shelf S.* 104, 160-167.
2. Del Río, L., Gracia, F.J., & Benavente, J. (2012). Shoreline change patterns in sandy coasts. A case study in SW Spain. *Geomorphology.* 196, 252-266.
3. Gonçalves, J.A. & Henriques, R. (2015): UAV photogrammetry for topographic monitoring of coastal areas. *ISPRS J. Photogramm. Remote Sens.* 104: 101-111.
4. Mancini, F., Dubbini, M., Gatelli, M., Stecchi, F., Fabbri, S. & Gabbianelli, G. (2013): Using Unmanned Aerial Vehicles (UAV) for high-resolution reconstruction of topography: The structure from motion approach on coastal environments. *Remote Sens.* 5(12), 6880-6898.

VERY HIGH-RESOLUTION AEROPHOTOGRAMETRIC SURVEY OF THE 2014/2015 LAVA FLOW FIELD OF FOGO VOLCANO (CAPE VERDE)

Gonçalo Vieira[1] , Pedro Pina[2], Carla Mora[3], Rui Fernandes[4] , Pedro Almeida[5], Stéphanie Dumont[6], Bento Martins[7], Carla Candeias[8], Carlos Oliveira[9], Ricardo S. Ramalho[10]

[1] CEG/IGOT, Universidade de Lisboa (Portugal), vieira@campus.ul.pt
[2] CERENA/IST, Universidade de Lisboa (Portugal), ppina@tecnico.ulisboa.pt
[3] CEG/IGOT, Universidade de Lisboa (Portugal), carlamora@campus.ul.pt
[4] UBI/IDL/C4G, Universidade da Beira Interior (Portugal), rui@segal.ubi.pt
[5] UBI/Geobiotec, Universidade da Beira Interior (Portugal), ct1fyw@segal.ubi.pt
[6] UBI/Geobiotec, Universidade da Beira Interior (Portugal), sd@hi.is
[7] Universidade de Aveiro (Portugal)
[8] Universidade de Aveiro, (Portugal), clcandeias@gmail.com
[9] Instituto Nacional de Gestão do Território (Cabo Verde)
[10] Instituto Dom Luiz, Faculdade de Ciencias, Universidade de Lisboa (Portugal), Ric.Ramalho@bristol.ac.uk

Key-Words: “Pico do Fogo volcano”;” 2014-15 eruption”; “Fixed-wing SenseFly ebee”; “Orthophotomosaic”; “Digital surface model”; Geological and geomorphological mapping”; “Lava flow modelling”

ABSTRACT:

Chã das Caldeiras is a flat and lava-infilled high altitude summit depression at Fogo volcano (Cape Verde), being the site of numerous historical volcanic eruptions. The depression is surrounded by the horseshoe-shaped Bordeira, a steep rockwall over 1,000 m high, which opens to the east, where the younger Pico do Fogo volcano (2829 m) presently stands. Fogo shows recurring volcanic activity, with the latest events in 1995 and 2014-15, both of which produced extensive lava flow fields at Chã das Caldeiras. Three settlements existed in Chã das Caldeiras prior to the 2014-15 eruption: Bangaeeira, Portela and Ilhéu de Losna. With a population of about 1200 inhabitants, their economy was based in agriculture (mainly wine and fruit orchards), grazing, and in tourism. The 2014-15 eruption lasted from 23 November 2014 to 7 Februrary 2015, with the active vents located in the western flank of Pico do Fogo.

The resulting lava flow field affected an area of ci. 4.5 km2 spreading along three main directions S, N, and W. In the framework of the project FIRE – Fogo Island Volcano: multidisciplinary research on the 2014 eruption (FCT - PTDC/GEO-GEO/1123/2014) our team surveyed Chã das Caldeiras in December 2016 using a fixed-wing SenseFly ebee, with the purpose of generating a very high-resolution orthophotomosaic and digital surface model of the area affected by the lava flows. The survey involved a total of 21 flights at an average altitude of 190 m, resulting in over 3,800 vertical aerial photos with an average gsd of 6 cm.

Ground control points were measured at artificial markers distributed in the field prior to the survey, or at easily-identifiable points, such large blocks or building edges, with a Leica Viva DGPS using a base station and a rover in RTK mode. Two cameras were used: a Canon G9X 16MP, which showed a serious internal failure, and a replacement Canon IXUS 12 MP. At the time of abstract submission, we are still generating the final products, but partial sectors of the study area have been already processed, with 7.5 cm GSD and a RMS error of 0.03 m. For accuracy assessment, we have used checkpoints, with results showing RMS errors of 0.077m (X), 0.082 (Y) and 0.035 (Z). Processing was done using PIX4D mapper 3. Despite the overall excellent quality of the results, some areas showed significant problems in the point cloud generation due to the smoothness of ground surfaces. This occurred especially in homogeneous accumulations of volcanic ash

and lapilli. At some sites at the overlapping boundaries between contiguous flights conducted at different hours, shadowing also induced artifacts. These areas correspond to a very small fraction of the surveyed area (still under assessment) and the solutions that have been applied to mitigate this issue include manually adding tiepoints and cleaning the point cloud. Lava flows (a'a and pahoehoe) and other features with surface roughness showed excellent results. This communication will focus on the surveying strategy and procedures applied to mitigate the issues found in the point cloud, and will include the presentation of the final orthophotomosaic and digital surface model. These products will be used for geological and geomorphological mapping, management and planning, and lava flow modelling.

LEVEE RISK AREA DETECTION BASED ON THE UAS PLATFORM DATA - INTEGRATION OF MULTISPECTRAL IMAGERY AND LIDAR POINT CLOUD

Bakuła Krzysztof[1] , Salach Adam[1] , Pilarska Magdalena[1] , Kurczyński Zdzisław[1]

[1] Faculty of Geodesy and Cartography, Institute of Photogrammetry, Remote Sensing and Spatial Information Systems, Warsaw University of Technology, Pl. Politechniki 1 00-661 Warsaw, Poland, k.bakula@gik.pw.edu.pl, adam.salach@pw.edu.pl, magdalena.pilarska@pw.edu.pl, kurczynski@wp.pl

Key-Words: UAS; LiDAR; photogrammetry; levee monitoring;

ABSTRACT:

Nowadays, levee monitoring can be successfully conducted with the usage of remote sensing techniques. Therefore, in most cases aerial photogrammetric data are used – particularly high resolution aerial imagery and airborne laser scanning (ALS) point clouds. Unfortunately, the disadvantage of the presented approach is the frequency of data acquisition. Usually photogrammetric flights are performed every few years for the same area. For corridor objects, such as levees, acquiring data with an Unmanned Aerial System (UAS) may become a more cost-efficient alternative to high altitude photogrammetry. As a result of collecting data more often and regularly, it is possible to assess flood hazard more effectively in the levee risk area.

This paper presents the methodology of levee risk area detection based on multispectral imagery and the LiDAR point cloud obtained from the UAS platform. In this experiment, UAS data were used after being acquired from the UAS platform equipped with a Riegl VUX-1 laser scanner and digital camera operating in the optical spectrum. The data covered a few kilometres of the levees. ALS point clouds were used for the generation of a high-accuracy Digital Terrain Model (DTM), and images were used for creating the RGB orthomosaic. The main goals of the analysis were the inventory and detection of geometric changes in levees' surfaces that may indicate the levee damage. Thus, two DTM models from different terms were compared: the first one was generated from the ALS point cloud obtained in 2011 and the second DTM was delivered from the Unmanned Laser Scanning (ULS) data. The assumed acceptable difference in heights between two DTMs was 25 cm, including the accuracy of airborne laser data and ULS data. However, the accuracy of the generated DTMs is also influenced by the ground filtration in the LiDAR data caused by dense vegetation, which results in decimetre differences between the models. Therefore, it is necessary to verify the areas of potential levee hazard, using image data. Archival and new mosaics were converted to Global Vegetation Index (GVI) raster datasets, using pixel values in the red and green bands of the acquired images. In the next step, the GVI raster files were reclassified and two classes were distinguished: bare soil and other land cover. There were problems with indicating one, constant GVI threshold for bare soil because this value depends on the season and current atmospheric conditions. Upon including the index level, it was possible to skip the radiometric calibration and normalization of the index value. The result of this step is creating a bare soil mask, and subsequently detecting the bare soil areas which were not appearing on the previous data. The final result of the conducted spatial analysis is the localisation of areas for which the change in height (geometry) correlates with the emerging bare soil.

The presented methodology applies to the system of levee monitoring being created. In this system, multispectral information including the near infrared spectrum will be used. The proposed methodology of the levee risk area detection shows significant potential because the results of this methodology are not influenced by the existing conditions, time of data acquisition or by using different types of sensors.

UAS-BASED CHANGE DETECTION OF THE LÄRCHBERG-GALGENWALD LANDSLIDE, AUSTRIA

Gernot Seier(1), Wolfgang Sulzer(2), Paul Lindbichler(3), Josef Gspurning(4)

(1) Department of Geography and Regional Science, University of Graz, Heinrichstr. 36, 8010 Graz, Austria, gernot.seier@uni-graz.at
(2) Department of Geography and Regional Science, University of Graz, Heinrichstr. 36, 8010 Graz, Austria, wolfgang.sulzer@uni-graz.at
(3) Department of Geography and Regional Science, University of Graz, Heinrichstr. 36, 8010 Graz, Austria, paul.lindbichler@edu.uni-graz.at
(4) Department of Geography and Regional Science, University of Graz, Heinrichstr. 36, 8010 Graz, Austria, josef.gspurning@uni-graz.at

Key-Words: Unmanned aerial systems; landslide; change detection; DEM differencing; SfM-photogrammetry;

ABSTRACT:

UAS (unmanned aerial systems) became an established method in research-related studies during the last years. Geomorphological issues are nowadays often assessed based on UAS-data. Numerous articles deal with UAS-based detection or monitoring of landslide-induced changes of the earth surface, e.g., [1], [2] or [3].

The landslide Lärchberg-Galgenwald is a well-investigated site located in Upper Styria, Austria. The steep slope, which is approximately 9 ha large, is characterized by unstable rock material with diverse activity and types of mass movements and endangers a frequently used main road located right beneath the landslide. Zones of different activity can be distinguished as follows: a main active zone of a rotational rockslide with downward mass movement of about 30 cm a^{-1} that is surrounded by zones with decreasingly lower activity (Hermann 2004 in [4]). The instability of the slope arises mainly from geological conditions: a formation of marbles resting on phyllites that are interlayered by graphitic schists [4]. In April 2001 rock blocks with the size of a few cubic meters damaged the area next to the road [4]. Initialized by this rock fall, this slope was intensively investigated and moreover the access is prohibited since that event. As further consequence, a dam was built in order to prevent the main road being affected by rock falls. Since 2001, the methods applied to assess the landslide's acitivity comprised mainly measurements of a servo-driven theodolite (about 40 fixed points) and measurements of wire extensometers (10 wires), apart from an additionally installed precipitation measuring instrument and computational model simulations. These geodetic and geotechnic methods applied have the following disadvantages: they are related to some specific points only, the mentioned theodolite is cost-intensive in terms of purchase and maintenance and furthermore the extensometers need to be installed in situ, which is according to the high activity a difficult and dangerous situation. Thus, alternative methodological approaches were needed. This study contributes to these pending questions. Accordingly, the Lärchberg-Galgenwald landslide was for the first time recorded by a UAS to acquire high resolution data with a reduced in situ time. A main benefit of aerial photographs is that they are not limited to some points only, but are area-related.

We focused on the main area with highest activity that is characterized by a rock surface to (1) detect changes of the landslide's surface, (2) assess the accuracy of the resulting data in order to ensure correct data interpretation, (3) point out whether a UAS-based recording is really favourable compared to common terrestrial methods or whether it could additionally be used for monitoring purposes and (4) assess whether the number of ground control points (GCPs) could be reduced during processing of follow-up UAS-data. The latter would especially reduce the personnel and equipment needed.

We carried out two UAS-flight campaigns in November 2015 (11/2015) and May 2016 (05/2016) using a multirotary UAS. It took several challenging flights to cover the study area due to the steep topography. The UAS had to be operated maximum 150 m above ground that was in some cases about 320 m above the starting and pilot's position. A precondition for operating the UAS was that the nearby road was temporarily blocked during flights. We processed the UAS-photographs based on Differential Global Positioning System (DGPS)-measurements of GCPs (n = 15 (11/2015), 25 (05/2016)) to ensure precise indirect georeferencing. We generated digital elevation models (DEMs) and orthophotos with a ground sampling distance (GSD) of 4 cm by using structure-from-motion (SfM)-photogrammetry. We assessed the accuracy of resulting DEMs and orthophotos based on independent geodetic check points (n = 173), geodetic profiles and root mean square errors (RMSEs) of GCPs. The standard deviation (SD) of the elevation differences of geodetic check points to DEMs is 9 cm. The differences of geodetic profiles are in a range of a few centimetres. The same statement can be made for the RMSEs (horizontal and vertical). In addition, for reasons of comparison we made records from the opposite valley side using terrestrial laser scanning (TLS).

By using DEM differencing we calculated a vertical difference that was in most cases in the range of a few centimetres even if some changes were detected with larger vertical differences. The latter relates mainly to moving single objects such as rock blocks or tree trunks. Apart from that a general surface elevation lowering was not detectable. Based on the resulting orthophotos we calculated vectors of horizontal displacement using normalized cross correlation (NCC), see, e.g., [5]. The displacement direction indicates a general downward movement and the displacement distances were in most cases in a range of a few centimetres only. Thus, a noteworthy general downward movement cannot be shown for that period in time between 11/2015 and 05/2016.

Even though overall changes of the landslide's surface are small and thus not evidently detectable, the movement of single obstacles such as rock blocks and tree trunks is clearly measureable. A combination with the mentioned commonly used terrestrial methods is in the present case still necessary due to vegetation coverage surrounding the main active area and because specific sections of the slope are only quantifiable by applying these high-precision methods. But in addition the UAS-based results fill the data gaps between these measurements. The diverse validation approaches confirmed the accuracy of the resulting data. First results of processing with a reduced number of GCPs indicate that the time in situ can be minimized in upcoming field campaigns (see, e.g., [6]). Thus, the need for an additional UAS using direct georeferencing is not essential. As a conclusion, we can remark that the multirotary UAS used is applicable to widen the methodological approaches of change detection and monitoring on a large scale in context of Lärchberg-Galgenwald landslide. UAS-based data enhance the previous data base and hence provide the basis for a more comprehensive assessment of the landslide's activity. For example, the detected mass movements refer mainly to single rocks that are not noticeable with previously used methods. Therefore, we formed the basis for a future monitoring programme including UAS. Figure 1 summarizes the main mentioned points of this abstract.

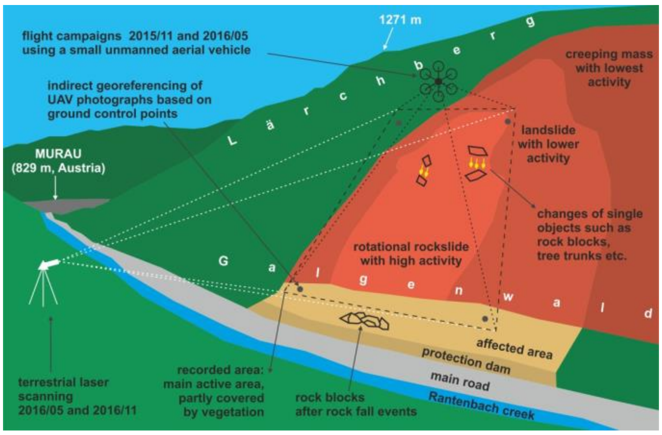


Figure 1. Graphical abstract of the UAS-based study at Lärchberg-Galgenwald.

References:

1. Niethammer, U., James, M.R., Rothmund, S., Travelletti, J. & Joswig, M. (2012). UAV-based remote sensing of the Super-Sauze landslide: Evaluation and results. *Engineering Geology* 128, 2–11. doi:10.1016/j.enggeo.2011.03.012
2. Turner, D., Lucieer, A. & de Jong, S.M. (2015). Time Series Analysis of Landslide Dynamics Using an Unmanned Aerial Vehicle (UAV). *Remote Sensing* 7(2), 1736-1757. doi:10.3390/rs70201736
3. Lindner, G., Schraml, K., Mansberger, R. & Hübl, J. (2016). UAV monitoring and documentation of a large landslide. *Applied Geomatics* 8(1), 1–11. doi:10.1007/s12518-015-0165-0
4. Poisel, R., Angerer, H., Pöllinger, M., Kalcher, T., & Kittl, H. (2009). Mechanics and velocity of the Lärchberg–Galgenwald landslide (Austria). *Engineering Geology* 109, 57–66. doi:10.1016/j.enggeo.2009.01.002
5. Debella-Gilo, M. & Kääb, A. (2011). Sub-pixel precision image matching for measuring surface displacements on mass movements using normalized cross-correlation. *Remote Sensing of Environment* 115, 130–142. doi:10.1016/j.rse.2010.08.012
6. James, M.R., Robson, S., d'Oleire-Oltmanns, S. & Niethammer, U. (2017). Optimising UAV topographic surveys processed with structure-from-motion: Ground control quality, quantity and bundle adjustment. *Geomorphology* 280, 51–66. doi:10.1016/j.geomorph.2016.11.021

UAS IDENTIFICATION OF LIANA INFESTATION IN TROPICAL FORESTS, MALAYSIA

Catherine Waite[(1)], Doreen Boyd[(1)], Geertje van der Heijden[(1)], Richard Field[(1)]

[(1)]School of Geography, University of Nottingham, Nottingham, NG7 2RD, UK.
Emails: catherine.waite@nottingham.ac.uk, doreen.boyd@nottingham.ac.uk, geertje.vanderheijden@nottingham.ac.uk, richard.field@nottingham.ac.uk

Key-Words: lianas; tropical forest; carbon; climate change; Malaysia

ABSTRACT:

The critical role played by the spread of woody vines (lianas) in dramatically reducing the carbon uptake of the world's tropical forests is not widely recognised, despite the wealth of research on global warming. The importance of understanding the ecology of tropical forests is unequivocal: they are major carbon sinks, storing more than 30% of terrestrial carbon. However, an increase in liana abundance over the past decade has altered forest structure throughout the tropics, reducing both carbon accumulation and long-term storage. Lianas reduce carbon stocks by climbing up to the canopy where they shade tree leaves, decreasing tree growth by up to 84% and increasing tree mortality. Furthermore, by using the trees for support, lianas can allocate a higher proportion of biomass to foliage production over carbon-dense, structurally supportive, stem production. Thus, they fail to replace the biomass lost through tree mortality and reduce above-ground carbon uptake by as much as 76%/year. The net effect is to release carbon previously stored in tropical forests into the atmosphere, with important and wide reaching impacts for global warming.

Despite this, lianas are chronically understudied in tropical forest ground-based censuses due to the time-consuming nature of surveying them. While mapping and monitoring studies utilising satellite and airborne images have occurred, they are limited by relatively coarse spatial and temporal resolutions, cloud obscuration, and high costs. Resultantly, there is a lack of data on the scale and impacts of recent liana proliferation. UAS imaging may provide an affordable and accessible tool to map and monitor lianas at higher spatial and temporal resolutions than possible with ground-based censuses, while overcoming the limitations associated with airborne and satellite techniques.

Combining UAS and ground-based canopy censuses in 17 plots, covering over 11 ha, in two areas of tropical forest (Danum Valley and Sepilok) in Malaysia, this research will investigate whether liana load (estimated as % crown cover) can be accurately distinguished using UAS imagery. It aims to assess the viability of an UAS as a tool for mapping and monitoring lianas in tropical forests while providing information on the extent and spatial patterning of liana infestation. The ability to repeatedly and accurately map lianas is crucial for analysing and quantifying their effects on forest function, while helping uncover mechanisms behind their proliferation, as a continued increase may further reduce tropical forest carbon storage and sequestration, thus endangering the future of the tropical carbon sink.

Liana load of all trees ≥10cm (dbh) in each plot were classified in ground-based censuses using three methodologies: crown occupancy index (COI); crown cover survey (CCS); and detailed liana measurements (DLM). COI is a relatively fast characterisation, based on an ordinal scale index, where each tree received a score depending on the percentage of the crown covered by lianas (0 = 0%, 1 = 0-25%, 2 = 26-50%, 3 = 51 – 75%, 4 = >75%). CCS is a more detailed measure, where tree crowns were split into four quadrants and the % crown cover of lianas for each estimated to the nearest 5%. For DLM, in order to relate the UAS-derived % crown cover data to comparable ground-derived data of liana basal area in tree crowns, all lianas <1m from the tree truck were counted and their diameter measured at the thickest point. UAS-surveys were conducted

and the images processed to create orthomosaics of each plot with spatial resolutions of ~3cm. The % crown cover of lianas was estimated from the UAS images using the COI and CCS methodologies and linked to the ground data to determine whether there was a relationship between them, and thus whether the UAS methodology provided accurate data on liana loads. Preliminary results indicate strong, positive correlations (R^2 ranging from 0.68 to 0.83, p = <0.001) between ground and UAS-based measures of liana load, on individual tree and plot-based levels, for all three measures. These encouraging results suggest UAS imaging is an affordable, accessible, and rapid new method for collecting data on liana canopy cover in tropical forests.

USING A UAV TO MONITOR TEMPERATE INTERTIDAL HABITATS: AN ASSESSMENT OF PHOTOGRAMMETRY AND OBJECT-BASED IMAGE ANALYSIS

Paula Lightfoot[(1)] , Nicholas V C Polunin[(1)], Catherine L Scott[(2)], Clare Fitzsimmons[(1)]

[(1)] School of Marine Science and Technology, Newcastle University, Armstrong Building, Newcastle upon Tyne, NE1 7RU, United Kingdom, marine@ncl.ac.uk
[(2)] Natural England, Lancaster House, Hampshire Court, Newcastle upon Tyne, NE4 7YH, United Kingdom

Key-Words: Coastal; Intertidal; Marine Protected Area; Object-based image analysis; Rugosity; Biotopes; Photogrammetry

ABSTRACT:

Temperate intertidal habitats support high levels of biodiversity and provide important ecosystem services but are vulnerable to anthropogenic degradation. However, the intertidal zone is more amenable to management than the subtidal, and much of Europe's coastline is designated for biodiversity conservation with concomitant requirements for surveillance and monitoring.

Two widely used measures of conservation value are topographic complexity and habitat diversity, which are strongly correlated with biodiversity in marine environments. Monitoring these features in the intertidal zone presents particular challenges; survey times are restricted by the tidal cycle, large stretches of coastline are inaccessible on foot, it is a highly dynamic environment requiring frequent repeat surveys and both topography and habitats can be heterogeneous on a very fine spatial scale. UAV technology could provide a cost-effective, flexible solution to these challenges.

Taking a Marine Protected Area on the English east coast as a study site, high resolution multispectral imagery was collected using a lightweight fixed-wing UAV with a consumer-grade digital camera. Two data interpretation methods were evaluated:

To assess topographic complexity, photogrammetry was used to create high resolution georeferenced 3D terrain models. Vertical accuracy was validated by comparison with ground truth samples. Linear rugosity (surface roughness) indices derived from these models were compared with indices derived from manual measurements and the root mean square error (RMSE) was calculated.

To assess habitat diversity, object-based image analysis (OBIA) workflows were developed using ecological knowledge to interpret UAV imagery to map intertidal habitats at broad and fine thematic scales. Outputs were compared to ground truth data to evaluate the accuracy, consistency and reproducibility of three supervised classification approaches.

Photogrammetry produced terrain models with a high degree of vertical accuracy (RMSE from 0.06m to 0.13m). Rugosity measurements derived from photogrammetry were variable and affected by user-defined data processing parameters. RMSE of surface length ranged from 0.19m to 0.33m, representing 3.8% to 6.5% of the sampling distance. Despite variability in centimetre-scale rugosity measurements, ecologically important decimetre-scale features such as small channels, steps and boulders were consistently detected.

OBIA methods applied to the orthomosaic imagery and terrain models produced robust broadscale habitat maps (mean accuracy 83.4% ± 3.8%). The production of fine scale biological community maps was more challenging, but a Random Forests classifier produced promising results (mean accuracy 60.5% ± 2.6%).

The application of photogrammetry and OBIA methods to UAV imagery holds great potential for measuring topographic complexity and mapping the distribution of intertidal species and habitats, providing valuable information to underpin the designation, management and monitoring of temperate Marine Protected Areas.

CAN DRONES BE USED TO ESTIMATE ORANGUTAN DENSITIES?

Serge A. Wich[1,2], Molly E. Hennekam[3], Matt Nowak[4,5], Keeyen Pang[6], Alexandra Robinson[1], Graham Usher[3], Benoit Goossens[7,8,9], Danica J. Stark[7,8], Marc Ancrenaz[10], and Lian Pin Koh[3]

[1]Liverpool John Moores University, School of Natural Sciences and Psychology, James Parsons Building, Byrom street, L33AF, Liverpool, UK, s.a.wich@ljmu.ac.uk
[2]Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Sciencepark 904, Amsterdam 1098, the Netherlands
[3]School of Biological Sciences, University of Adelaide, South Australia 5005, Australia, molly.hennekam@adelaide.edu.au, lianpin.koh@adelaide.edu.au
[4]Sumatran Orangutan Conservation Programme, Jl. Wahid Hasyim 51/74. 20154 Medan, North Sumatra, Indonesia, nowak.mg@gmail.com
[5]Southern Illinois University, Department of Anthropology, 1000 Faner Drive, Carbondale, IL, 62901, USA
[6]Hornbill Surveys Sdn Bhd, Lot 9, Harapan Baru Light Ind Estate, Mile 8, Jalan Labuk, Sandakan 9009, Malaysia, hornbillsurveys@gmail.com
[7]Danau Girang Field Centre, c/o Sabah Wildlife Department, Wisma Muis, Block B 5th Floor, Kota Kinabalu 88100, Sabah, Malaysia, GoossensBR@cardiff.ac.uk, danicastark@gmail.com
[8]Organisms and Environment Division, Cardiff School of Biosciences, Cardiff University, Sir Martin Evans Building, Museum Avenue, Cardiff CF10 3AX, UK
[9]Sustainable Places Research Institute, Cardiff University, 33 Park Place, Cardiff CF10 3BA, UK
[10]HUTAN, Kinabatangan Orang-utan Conservation Programme, Sabah, Malaysia, marc.ancrenaz@gmail.com

Key-Words: Orangutans, Sumatra, Borneo, Aerial survey, nest count,

ABSTRACT:

Both orangutan species (Pongo abelii and P. pygmaeus) are now considered critically endangered. Even though our knowledge about their distribution and density has increased enormously during the past two decades, gaps still exist and trend monitoring remains rare due to the high costs of survey work. Here we report the results from a study on the islands of Sumatra (Sikundur) and two sites in the Lower Kinabatangan Wildlife Reserve (LKWS) Borneo that compared orangutan nest densities from ground nest surveys and aerial nest surveys using fixed-wing drones. The results show that for Sumatra and one of the Bornean sites (Lot 2 of LKWS) the nest densities from ground counts are significantly higher than densities derived from drones. For the second Bornean site (Lot 6 of LKWS), there is a trend in the same direction, although it is not statistically significant. There is a significant positive relation between ground and aerial nest density for Borneo but not for Sumatra. Between site comparisons show that the ground nest density at Lot 2 is significantly higher than at Sikundur and LKWS' Lot 6; Sikundur has a significantly higher ground density then Lot 6. Aerial densities did not differ significantly between Lot 2 and 6, but Sikundur (Sumatra) has a significantly higher aerial nest density than either Bornean site. We discuss these results with respect to habitat and nesting differences between the islands and make recommendations on how aerial surveys can be improved and what the limitations of the current method are.

ADAPTING ASTRONOMICAL SOURCE DETECTION TECHNIQUES TO DETECT UNRESOLVED ANIMAL SOURCES IN THERMAL IMAGES OBTAINED BY UNMANNED AERIAL SYSTEMS

M. Rashman(1), M. de Juan Ovelar(1), S. Wich(2), S. N. Longmore(1)

(1) Astrophysics Research Institute, Liverpool John Moores University, 146 Brownlow Hill, Liverpool, L3 5RF, UK, M.F.Rashman@2016.ljmu.ac.uk, S.N.Longmore@ljmu.ac.uk
(2) School of Natural Sciences and Psychology, Liverpool John Moores University, Liverpool, UK

Key-Words: Conservation; Thermal Imaging; Automated Pipeline

ABSTRACT:

Recently conservation scientists have started to use thermal imaging sensors to monitor wildlife from UAVs. The spectral energy distribution of warm-blooded vertebrates peaks at wavelengths within the thermal infrared range making this the ideal wavelength to monitor vulnerable species in the field of conservation biology. Using UAVs (unmanned aerial vehicles) and “thermal”-infrared cameras, high volumes of biodiversity survey data can be obtained for a fraction of the time and cost of more traditional methods; however data analysis techniques are poorly developed and thus greatly increase the time taken to extract meaningful scientific output which potentially could offset the gains made on the data acquisition side. Astronomical source detection techniques are well developed for the detection and identification of astronomical bodies at infrared wavelengths and have been successfully automated for many years. Building on the work of [1] we are adapting our knowledge of and experience using infrared data in astronomy to fully automate the detection and identification of warm blooded vertebrates in terrestrial infrared data collected by UAVs. Working with survey footage, we aim to evaluate the physics behind the intensity emitted by animals at these wavelengths and to investigate how unique this is to each species. To evaluate the physical aspect of fauna detection we first have to understand the relationship between the intensity we observe and the true emitted intensity of the subject. Much like stars, the observed flux is highly dependent on both the camera resolution and the atmosphere between the subject and the camera. If objects are poorly resolved a higher surface area is recorded per pixel and the flux averaged, resulting in measured temperature values that depend on the temperature of the surrounding environment. In addition to this the emitted flux is subject to radiative transfer effects such as the absorption and emission processes of the air column between the camera and subject. To fully understand these effects on the intensity and temperature values we are working closely with Knowsley Safari Park in Merseyside, England to study a range of animal species. In this talk we will present our results from modelling these effects. To conclude we will discuss how critical a role they play in transforming observed intensity values into accurate animal temperatures, and how we can adapt this knowledge to correct for these effects in real bio-diversity survey data.

References:

1. Longmore, S.N., R.P. Collins, S. Pfeifer, S.E. Fox, M. Mulero-P´azm´any, F. Bezombes, A.Goodwin, M. de Juan Ovelar, J. H. Knapen, and S. Wich. 2017. “Adapting astronomical source detection software to help detect animals in thermal images obtained by unmanned aerial systems.” International Journal of Remote Sensing

TESTING THE FEASIBILITY OF UNMANNED AERIAL VEHICLES AND THERMAL IMAGING FOR UNGULATE SURVEYS

Julia Witczuk(1) , Stanisław Pagacz (1), Anna Zmarz (2) , Maciej Cypel (3)

(1)Museum and Institute of Zoology, Polish Academy of Sciences, Warsaw, 00-679, Poland; juliawit@miiz.eu
(2)University of Warsaw, Faculty of Geography and Regional Studies, Department of Geoinformatics, Cartography and Remote Sensing, Warsaw, 00-927, Poland; azmarz@uw.edu.pl
(3) Taxus SI, Warsaw, 02-491, Poland; mcypel@taxusul.com.pl

Key-Words: Unmanned aerial vehicles; Thermal imaging; Monitoring

ABSTRACT:

The reliable assessment of population size is required for effective ungulate management and conservation. Yet, none of the several ungulate monitoring methods is satisfying in terms of cost-effectiveness and precision. A new method combining unmanned aerial vehicles (drones) and thermal infrared (TIR) imaging may have great potential as a tool for ungulate surveys. In addition to having all of the advantages of aerial surveys, it also enables operations at night, when ungulates are most active and easy to detect. To assess the feasibility of the proposed method we used fixed-wing drones with TIR cameras to conduct test surveys in Drawieński National Park, Poland. We detected animals both in leafless deciduous and in pine-dominated coniferous forests. Survey timing highly influenced the results – the best quality thermal images were obtained at sunrise, late evening and at night. Our preliminary results show that drones with TIR sensors are a suitable tool for ungulate surveys. We demonstrated that with ground resolution of ~10 cm it is possible to distinguish large species (i.e. red deer) and achieve a good level of area coverage. The main challenges of the method are difficulties in species identification due to relatively low resolution of TIR cameras, regulations limiting drone operations to visual line of sight, and high dependence on weather.

UAV BASED SURVEY OF THE WEST ANTARCTIC ENVIRONMENT

Anna Zmarz[1] , Mirosław Rodzewicz[2], Małgorzata Korczak-Abshire[3], Katarzyna Chwedorzewska[3], Maciej Dąbski[4], Izabela Karsznia[1]

[1]University of Warsaw, Faculty of Geography and Regional Studies Department of Geoinformatics, Cartography and Remote Sensing, Warsaw, Poland; azmarz@uw.edu.pl
[2]Warsaw University of Technology, Faculty of Power and Aeronautical Engineering, Department of Aircraft Design, Warsaw, Poland; miro@meil.pw.edu.pl
[3] Institute of Biochemistry and Biophysics Polish Academy of Sciences, Department of Antarctic Biology, Warsaw, Poland; mka@ibb.waw.pl
[4] University of Warsaw, Faculty of Geography and Regional Studies, Department of Geomorphology, Warsaw, Poland; mfdbski@uw.edu.pl

Key-Words: Unmanned aerial vehicle; Environment monitoring; Antarctica

ABSTRACT:

Project "A novel approach to monitoring the impact of climate change on Antarctic ecosystems" started in 2014/15 and has been conducted in three austral summer seasons. This project utilized Unmanned Aerial Vehicle (UAV) to collect geospatial environmental data and covered Antarctic Specially Protected Areas (ASPA) No. 128 and ASPA No. 151, on King George Island (1150 km2) and Penguin Island, South Shetland Islands, West Antarctica. The PW-ZOOM was designed as a platform to perform autonomous photogrammetry missions under harsh polar conditions. Flight have been designed over Penguin Island as Beyond Visual Light of Sight (BVLOS). The flight was made on 1st of December 2016, total time of flight mission lasted 2h 14 min. In this time the UAV reached the Penguin Island area located 30 km from the place of take-off and landing (the Arctowski Station). PW-ZOOM was used in order to estimate size of penguin and pinneped breeding populations, and to map landforms and vegetation cover. Images were taken with digital SLR Canon 700D with a 35mm objective lens. Flights altitude was 550 m above ground level (AGL) and ground sample distance (GSD) was less than 7 cm. Images of this GSD allowed us to locate and identify the individuals of two penguin species: Adélie (*Pygoscelis adeliae*) and chinstrap (*Pygoscelis antarcticus*), as well as the individuals of two species of pinnipeds: the southern elephant seal (*Mirounga leonina*) and the Weddell seal (*Leptonychotes weddellii*) rested on the shore. We mapped following geomorphological features: volcanic landforms and outcrops of volcanic rocks (e.g. volcanic cone, dykes, outcrops of different lavas and pyroclastic rocks, volcanic bombs), mass movement landfroms (landslide scar, scoria flow, solifluction terraces), fluvial landforms (e.g. erosional furrows, braided channels, dry valleys), coastal landforms (beaches, cliffs and rockfalls), dunes, snow patches, lake, and other surfaces. The Island is cover by typical for polar desert scatter tundra communities. At the flat coastal area develop communities dominate by fructose lichens with some tussock of Deschampsia antarctica, Colobanthus quitensis, with mosses patches in more humid and sheltered habitats. Around birds breeding colonies on rocks appeared ornitho-coprophilous likens. The slope and interior of the crater are practically devoid of vegetation. From UAV images we were able to map, only the vegetation patches the largest than 7 cm.

The research leading to these results has received funding from the Polish-Norwegian Research Programme operated by the National Centre for Research and Development under the Norwegian Financial Mechanism 2009-2014 in the frame of Project Contract No 197810.

UAV TECHNOLOGY FOR DETECTION AND CHARACTERIZATION OF PATOLOGIES IN PLATES OF THE CONCRETE COVERING OF SLOPES

Byron Morales[1] , Alfonso Tierra[1]

[1] *Universidad de las Fuerzas Armadas ESPE; (bomorales1, artierra)@espe.edu.ec*

Key-Words: Fissures, ortho-mosaics, slope, Pix4D, GPS, GIS, UAV

ABSTRACT:

The Ecuadorian Andes are located in a zone of great seismic activity; it has registered earthquakes up to magnitudes of 8.5. During rainy seasons, Ecuador can have pouring and continuous precipitations with an annual average of 1400 mm / m2. These natural hazards, together with the contribution of human infrastructure and buildings, are the main causes for waterlogged soils. Slopes over saturation cause instability on soils by its weight, as is often the case on mountain highways. Highways are often located in very steep slopes, conditioning soils' stability on steep slopes and slopes shield infrastructure. Seismic activity can also contribute as a trigger factor in the soils' stability.

Continuous precipitation and earthquakes and land shakes are very common in Ecuador, however, there are no studies that analyze and evaluate the conditions of stabilization works built and natural slopes in order to mitigate natural hazards through prevention and maintenance. When slopes monitoring does not exists, soil's instability can be of great magnitude as historically it has already happened. As a result, it is essential to first analyze soil's slopes to observe all soil's pathologies that can be generated by different causes. Later, an evaluation, locally or focally, of existing works in order to avoid damages and reduce possible human, infrastructure and environmental risks.

In the case of constructed works used in slopes' protection, a detailed diagnosis is necessary to identify the pathologies that could happen. Parameters such as degradation of shotcretes, shotcretes' fractures, or acid waters flow are factors that condition the slope stability. The presence of fissures and oxidation of the shotcrete poses a very important risk in human lives and road safety. Historically the instrumentation that has been used to detect these pathologies denoted high human labor risk, time costly and in some cases issues of accessibility. Using UAV technology, human risk can be avoided, is less time consuming, and facilitates data capture with greater accuracy, high resolution and in a detailed fashion. This eases risk analysis of slope landslides.

In this study, an analysis and evaluation of slope conditions is presented in order to identify the possible causes of soils' instability and risks with intervention and slope's protection infrastructure using UAV technology and photogrammetric techniques. This methodology helps to obtain information about areas with pathologies or degradation of shotcrete in slopes of a corridor located in the city of Quito-Ecuador. The methodology proposed in this study is designed in two steps: 1) Characterization and detection of fissures in the plates of concrete shotcretes through data analysis using UAV technology; 2) Inventory and characterization of elements and degradation parameters of the shotcrete, in potential zones of degradation and zones with high susceptibility by fracture of the concrete shotcretes.

A DJI Phantom 3 Professional was used to take slope imagines. The UAV has an integrated camera that includes a mechanical support that maximizes stability and minimizes weight and size. Ground control points were determined from GPS tracking with dual frequency equipment. Two geomorphological orthoses were obtained, vertical and oblique, with an angle of 45 ° taken at an average height of 2 meters, thus achieving 1.3 mm resolution. A sample of 17 fissures in the slope mosaic was tried with help of Geographic Information System (GIS) tools. In the field, 34 fissures were measured along the slope in order to determine the

difference between these and the measurements made in the GIS. An average error of 1.05 cm and 1.41 cm for oblique and vertical orthoseic were achieved respectively. Steel plates measurements of anchor bolts were distributed in slope’s body were also carried out, which have an average difference of 0.30 cm.

ASTRONOMY MEETS CONSERVATION BIOLOGY: THERMAL PROFILING AS A TOOL FOR THE AUTOMATED CLASSIFICATION OF SPECIES IN UAVS THERMAL FOOTAGE ANALYSIS PIPELINE

M. de Juan Ovelar(1), M. Rashman(1), S. Wich(2), S.N. Longmore(1)

(1) Astrophysics Research Institute, Liverpool John Moores University, 146 Brownlow Hill, Liverpool, L3 5RF, UK, M.DeJuanOvelar@ljmu.ac.uk, M.F.Rashman@2016.ljmu.ac.uk
(2) School of Natural Sciences and Psychology, Liverpool John Moores University, Liverpool, UK

Key-Words: Conservation; Thermal Imaging; Automated Pipeline

ABSTRACT:

A cornerstone for conservation biology is obtaining data which provides robust measurements of animal distributions and densities. The use of data obtained with UAVs (Unmanned Aerial Vehicles) to monitor wildlife around the world promises to revolutionise this field. One of the main limitations of this approach is the fact that this footage is commonly obtained at visible wavelengths. This limits observation to daylight hours, and suffers from low contrast issues between animals and background, considerably complicating automating the detection/classification steps in the data analysis. The use of thermal infrared (Th-IR) footage instead has the potential to help overcome some of these issues since animals naturally emit thermal radiation independently of the time of the day, and the contrast between this emission and the background can be much larger at these wavelengths. However the analysis of this type of data poses other challenges that have only recently started to be tackled. Building on the work of [1] we continue to develop a pipeline for the analysis of Th-IR video data of animals based on techniques widely used to analyse IR astronomical data. Here we report on initial analyses to use thermal profiling techniques of different species as a first-stage classification step for the pipeline. We test thermal profiling techniques on footage of different species and explore the dependencies of this method on parameters such as e.g., distance and viewing angle. I will conclude by discussing the strengths and weaknesses of this technique, specifically focussing on the limitations and what these imply for the optimal regimes in which this might be useful for conservation purposes.

References:

1. Longmore, S.N., R.P. Collins, S. Pfeifer, S.E. Fox, M. Mulero-P´azm´any, F. Bezombes, A.Goodwin, M. de Juan Ovelar, J. H. Knapen, and S. Wich. 2017. “Adapting astronomical source detection software to help detect animals in thermal images obtained by unmanned aerial systems.” International Journal of Remote Sensing

QUANTIFYING AND VALIDATING RAPID GEOMORPHIC EVOLUTION, A MONITORING AND MODELLING CASE STUDY

Rory Scott[1] , Neil Entwistle[1], George Heritage[2]

[1] University of Salford, Peel Building, University of Salford, Salford M5 4WT, UK
r.scott4@edu.salford.ac.uk, n.s.entwistle@salford.ac.uk.
[2] AECOM Consulting, Exchange Court, 1 Dale Street, Liverpool, L2 2ET, UK
george.heritage@aecom.com

Key-Words: Avulsion, Geomorphic, Evolution, Modelling, Monitoring, LiDAR, Management, Flooding;

ABSTRACT:

Gravel bed river systems present an ideal subject for development and improvement of rapid monitoring tools, with features dynamic enough to evolve within relatively short-term timescales. For detecting and quantifying topographical evolution, UAV based remote sensing has manifested as a reliable, low cost, and accurate means of topographic data collection. Here we present some validated methodologies for detection of geomorphic change at resolutions down to 0.01 m, building on the work of Wheaton et al. (2009) and Milan et al. (2007), to generate mesh based and pointcloud comparison data to produce a reliable picture of topographic evolution. Results are presented for the River Glen, Northumberland, UK. Recent channel avulsion and damage to flood defence structures make this site a particularly suitable case for application of geomorphic change detection methods, with the UAV platform at its centre. We compare multi-temporal, high-resolution point clouds derived from SfM processing, cross referenced with aerial LiDAR data, over a 1.5 km reach of the watercourse. Changes detected included bank erosion, bar and splay deposition, vegetation stripping and incipient channel avulsion. Utilisation of the topographic data for numerical modelling, carried out using CAESAR-Lisflood predicted the avulsion avulsion of the main channel, resulting in erosion of and potentially complete circumvention of original channel-and flood levees. Subsequent UAV survey highlighted topographic change and reconfiguration of the local sedimentary conveyor as we predicted with preliminary modelling. The combined monitoring and modelling approach has allowed possible future geomorphic configurations to be predicted permitting more informed implementation of management strategies.

CRUCIAL FACTORS TO CONSIDER DURING THE ASSESSMENT AND PROCUREMENT OF DRONE SYSTEMS FOR FORESTRY, CONSERVATION AND ENVIRONMENTAL APPLICATIONS EXEMPLIFIED IN THE CASE OF THE SETUP OF A MONITORING SYSTEM FOR A REGIONAL CONSERVATION AREA IN SAN MARTIN, PERU.

Patrick Ribeiro[(1)]

[(1)] OpenForests, patrick.ribeiro@openforests.com

Key-Words: drones, UAV, procurement, monitoring, conservation

ABSTRACT:

Having carried out a variety of drone-based works for different organizations worldwide, from the generation of 3D models of single trees to large-scale landscape mapping, we recognized that insufficient attention is given to the selection of appropriate drone equipment by newbies. In many cases, the acquisition choice of drone solutions is strongly driven by the marketing presence of certain dominating drone brands, rather than the compatibility of their specifications for a given application. The most striking example of such a mismatch is the acquisition of the top seller and well-known DJI phantom quadcopter, which has limited load capacity, as well as flight time and range, for the mapping of huge landscape areas, for instance for the monitoring of forests. In addition, an integrated approach of the use of drones within the broader context of remote sensing, where field survey and satellite data might play equally important roles, is usually missing.

Based on a case study carried out for the Regional Conservation Area Cordillera Escalera in San Martín, Peru, a territory of 150.000 ha with a harsh topography of difficult access, I will elucidate which set of criteria should be considered for the selection of drone systems compatible with the local conditions and the application goals. Furthermore, I will elucidate in which way drones can be employed as a powerful conservation monitoring tool to complement satellite and field-based remote sensing practices.

EVALUATION OF URBAN GREEN SPACES WITH UAV-BASED PHOTOGRAPHY, IN QUITO, ECUADOR

César Alvarez[1,2] , Richard Vilches[2], Xavier Cumbagin[2], Henry Mejia[2], Ana Teodoro[1,3]

[1] Department of Geosciences, Environment and Land Planning, Faculty of Sciences, University of Porto, 4169-007 Porto, Portugal

[2] Grupo de Investigación en Ciencias Ambientales (GRICAM), Carrera de Ingeniería Ambiental, Universidad Politécnica Salesiana, Quito, Ecuador; calvarezm@ups.edu.ec

[3] Earth Sciences Institute (ICT), Pole of the FCUP, University of Porto, Portugal; amteodor@fc.up.pt

Key-Words: Phantom 3; Urban Green Spaces; Quito; Orthomosaic

ABSTRACT:

Urban expansion influences a landscape's structure and function, covering soils, destroying natural vegetation and disrupting hydrological systems [1]. The multi-dimension of urban areas is a comprehensive composition of natural, built and social components considering that the social component is destroying the natural component.

UAV-based photography is an effective technique in environmental sciences to obtain areas with high precision and make a new idea in the photointerpretation field, where applications like vegetation mapping in a park or in a forest area can be summarized on occasion considering an orthomosaic interpretation in a Geographic Information System (GIS) [2]. In general this technique using single commercial Drones like Phantom 3 can provide images with high spatial resolution, which can help understanding complex landscape structures. In addition, because UAV flying altitudes tend to be low, UAV-based photography is rarely affected by cloud cover (a serious problem in equatorial latitudes) and flight campaigns can be more flexibly planned and manipulated [3].

In applications as territorial and landscapes studies the using of UAV-based photography could be considered, regarding that one of the inputs in the urban green spaces is the green area over parks in a city. The green space over an urban area is very important because it has a directly relationship with people quality of life [4].

In this work, the data collection was conducted based on a UAV imaging system DJI Phantom 3 Professional. The system comprises a RGB camera with 12.4 MP. This kind of UAVs can take off from and land vertically on a small open area and has an onboard flight controller with a compass and inertial, gyroscopic, barometric and GNSS sensors (GPS and GLONASS). The flight time with the current batteries is about 15 min. The field campaign was done in June, 2016, over Quito, Ecuador.

Quito is the capital from Ecuador, and has in 2017 close to 2.7 million people. It is known this city has a few of green areas in parks but they are not well distributed. Statistic Institute (INEC) estimated that urban green index space is from 21.66 m2 per person in Quito. This data was obtained considering the data of general census mapping. However, the problem is showed that general census mapping considering that a park is all green space without considering the presence of other spaces, like roads, courts, recreational areas, etc.

This study is focused in 11 big parks in Quito (larger than 1789 ha) considered as urban green areas. Parks are present in all the urban area, but poorly distributed (the south of the city has less than the northern part). The methodology employed in this work considered the Urban Green Index, expressed by the equation (1):

$$Urban\ Green\ Index = \frac{\text{Number of m2 in green urban areas}}{\text{Number of people in an area}} \quad (1)$$

Where, the "number of m2 in green urban area" in Quito, was obtained by UAV-based photography in each park. The aerial photos were taken with Phantom 3 professional UAV equipment and planning with DroneDeploy application. In this study wasn't considered Ground Control Points (GCPs) regarding the precision required that to this kind of environmental application.

Then, the orthomosaic was generated considering the Agisoft PhotoScan 1.1.4 software with 5 cm per pixel from spatial resolution from each park and then with ArcGIS 10.3 software each park was visually photointerpreted considering different areas: tree zone, grass areas, recreational zone, building areas, parking zone and intern roads. Fig.1 shows a zonification example in a park called La Armenia. The "number of people in an area" data was obtained with the governmental entities.

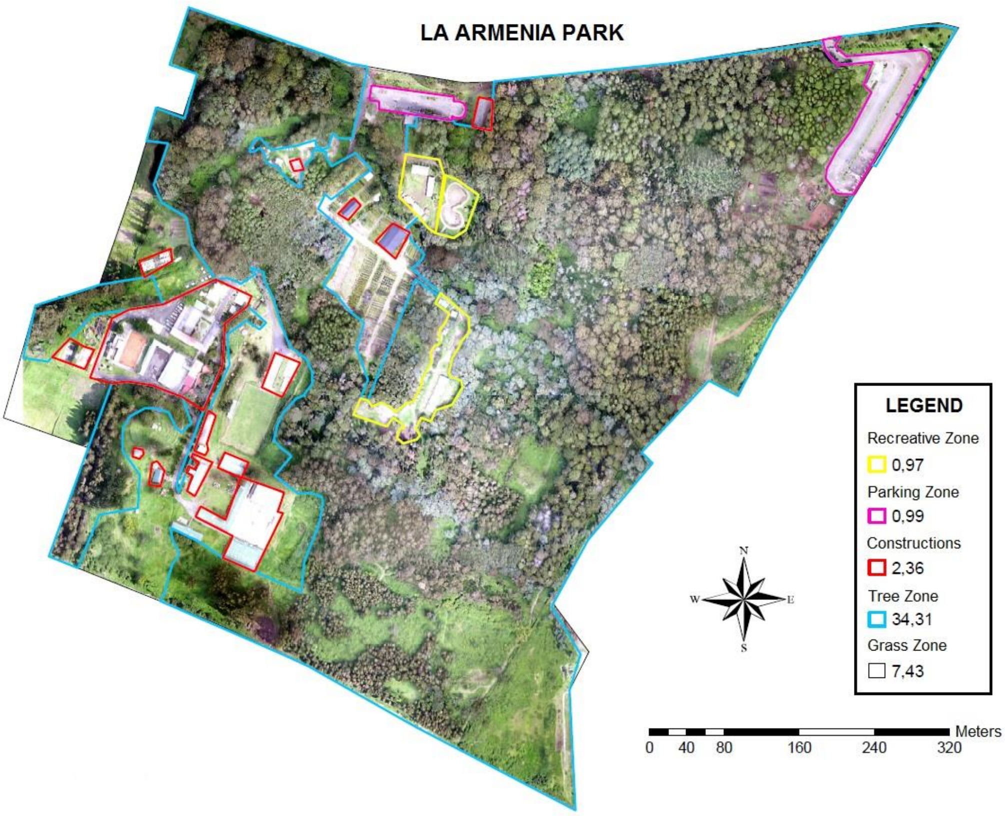


Figure 1. La Armenia Park zonification from Orthomosaic obtained with UAV Phantom 3. Areas showed in square meters.

The results with interpretation and calculation over high resolution orthomosaics show an urban green index space from 6.08 m2 per person, considering only the region of interest in parks like tree zones and grass, showing that in 2017 this index is lower than the recommendation of WHO, which is 9 m2 per person.

This study allowed to demonstrate that the urban green area in Quito don't have a correct environmental management by the local government and parks aren't correct distributed at large of city.

References:

1. Alberti, M.; Marzluff, J. M. Ecological resilience in urban ecosystems: Linking urban patterns to human and ecological functions. *Urban Ecosyst.* **2004**, *7*, 241–265.

2. Laghai, H.; Bahmanpour, H. GIS Application in Urban Green space Per Capita Evaluation (Case study :

City of Tehran). *Ann. Biol. Res.* **2012**, *3*, 2439–2446.

3. Rango, A.; Laliberte, A. Rangeland resource assessment, monitoring, and management using Unmanned Aerial Vehicle-based remote sensing. *… Remote Sens. …* **2010**, 608–611.

4. World Health Organization Urban green spaces and health: a review of the evidence. **2016**, 1:92.

HIGH RESOLUTION MAPPING OF GEOMORPHOLOGICAL HAZARD EXPOSURE OF ANTARCTIC INFRASTRUCTURES USING UAVS

Gabriel Goyanes[1,2,3], Gonçalo Vieira [3], João Branco [3], Simone Girst [3], Claudio Matko[1]

[1] Instituto Antártico Argentino – Dirección Nacional del Antártico (DNA-IAA), Av. 25 de Mayo 1143, CP 1650, San Martín, Buenos Aires, Argentina. E-mail: goyanes@campus.ul.pt
[2] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina
[3] Centro de Estudos Geográficos / Instituto de Geografia e Ordenamento do Território - Universidade de Lisboa, Portugal

Key-Words: Permafrost warming, Antarctic Peninsula, UAV

ABSTRACT:

Permafrost warming has been observed in recent decades in the Northern Hemisphere, but very little is known about trends in the Antarctic Peninsula region because of the scarce representativeness of the data in space and time. Unlike in the northern hemisphere, little is known on the effects of permafrost warming on infrastructures in the Antarctic Peninsula. This topic becomes overriding considering the air warming expected for the current century and the increase of human presence in the region. For these reasons, it is urgent to identify the areas more vulnerable to permafrost degradation and within those, to identify structures exposed to risk. Since regional maps cannot resolve the local factors involved in the development of hazardous processes affecting human infrastructure, detailed field analyses must be done.

UAV and DGPS surveying allow the generation of high resolution digital surface models and orthophoto mosaics. These maps are the base of the detailed geomorphological mapping, which through landform recognition supports the identification of permafrost degradation signs. These methods added to meticulous field surveys provides high quality results in short time, wide areal coverage and is of lower cost than traditional permafrost surveying.

We present the results obtained in the 2015-2016 summer Antarctic campaign with two UAV´s, a DJI Phantom 3 Advanced and a Sensefly Ebee. Ground control points were obtained using a Trimble DGPS. Autonomous flights were made at Gabriel de Castilla station (62º58'37.2"S, 60º40'31.5"W) and Decepción station (62º58'33.2"S, 60º40'55.4"W) in Deception island, Marambio station (64º14'30.2"S, 56º37'26.9"W) in Seymour island, Petrel station (63º28'26.7"S, 56º13'28.2"W) in Dundee island, Primavera station (64º09'20.9"S, 60º57'17.3"W) in Cierva cove and Yelcho station (64º52'33.3"S, 63º35'01.8"W) in Doumer island.

The orthophotomosaics and the detailed geomorphological mapping created from them allowed the identification of features related to permafrost degradation, such as thermokarst, valleys and gullies (thermo-erosional) close to buildings, some of which evidencing fractures or tilting that are hazardous to infrastructure.

DEVELOPMENT OF QGIS PLUGIN TO OBTAIN PARAMETERS/ELEMENTS OF TREETOPS WITH UAV IMAGERY

Silva, P.[(1)] , Teodoro, A.C[(2)], Duarte, L.[(3)], Moutinho, O.[(4)]

[(1)] Dep. Geociências, Ambiente e Ordenamento do Território, Rua Campo Alegre, 4169-007 Porto, Portugal, up201007485@fc.up.pt
[(2)] Dep. Geociências, Ambiente e Ordenamento do Território e Instituto Ciências da Terra (ICT), Rua Campo Alegre, 4169-007 Porto, Portugal, amteodor@fc.up.pt
[(3)] Dep. Geociências, Ambiente e Ordenamento do Território e Instituto Ciências da Terra (ICT), Rua Campo Alegre, 4169-007 Porto, Portugal, liaduarte@fc.up.pt
[(4)] Eye2Map, UPTEC Polo do Mar s/n, Av. Liberdade, 4450-718 Leça da PalmeiraPortugal, oscarmoutinho@eye2map.com

Key-Words: QGIS; image classification; trees metrics

ABSTRACT:

Imagery is a very common input data in Geographical Information Systems (GIS) applications. From imagery it is possible to obtain valuable information about the area that the imagery covers. Unmanned Aerial Vehicle (UAV) imagery was used as input data in GIS software. UAV imagery acquisition is easy to use with low cost acquisition and it can couple multiple sensors. Besides, it can be used in several areas like agriculture.

In this work, a GIS open source application was developed in QGIS software that estimates several parameters/metrics on treetops through image analysis techniques (image segmentation and image classification) and fractal analysis. The metric measurements that have been estimated were: area, perimeter, number of trees, distance between trees and a missing tree check. This methodology was tested on three different species of trees: olive, eucalyptus and vineyard.

The application developed is free, open source and takes advantage of QGIS integration with external software. Several tools available from ORFEO toolbox, SAGA and GRASS GIS were used to generate a classified raster image which allows to the user calculate the metrics referred before. The application is being developed in Python 2.7 language. Also, some functions, modules and classes from QGIS Application Programming Interface (API) and PyQt4 API were used.

To achieve the metric values intended, a methodology to get those values is required. First the given image was segmented applying a method of object-based image analysis, known as OBIA. This method is more suitable than the classification by pixel because it wants to consider elements like treetop as an element as a treetop has multiple pixels. Then, two kinds of image classification were tested (supervised image classification and the unsupervised image) to understand which image classification algorithm can get the best results.

The sample data for this tool was acquired in August 2016, from an organic olive oil producer, Acushla, from Vila Flor municipality, in the northeast of Portugal.

The data covers a 2.7ha parcel of “verdeal transmontana” olive trees, distributed in 48 lines, totalizing 777 trees, planted in 2010. Each tree is separated in line by 3.8m and between lines by 7m, with an average canopy area of 26.6m2.

The aerial survey was performed with an open source UAV platform, the Solo, from the company 3D Robotics. This is a multicopter UAV, with 4 motors and weighing 1.5kg (without payload), capable of 25

minutes flight. The camera used for the aerial survey was a MicaSense RedEdge, a multispectral sensor built specifically for UAVs with 5 individual bands: RED, GREEN, BLUE, NIR, REDEDGE.

The camera generates a 5-band conferenced tiff file. This geoinformation is provided by an external GNSS receiver that is directly connected to the camera.

The camera is attached to the Solo platform with custom designed 3D printed parts to absorb flight vibrations and hold the equipment, a combination of camera, GNSS receiver and a power bank in order to power the whole camera system, independently from the UAV battery.

When powered on, this camera has a wifi network that helps the user connect to it through a web interface, allowing configurations like the desired flight altitude, overlap and sidelap percentage between images. This information is essential to automatically calculate the distance that the UAV has to go through until the next trigger event. Thus, with the GNSS information, the camera is triggered whenever that distance is measured.

With the added weight from the camera system, the flight time capability is reduced to 15 minutes and the survey mission is planned for 10 minute flights for security measures. The combined weight from the UAV and camera system is 2kg. It used Mission Planner on computer and Tower on an android tablet, also open source ground control software for UAV, to create and monitor the flight path, with the same altitude and sidelap as it was configured in the multispectral camera.

To calculate the metric measurements, a tool is executed that makes a fractal analysis on images. The fractal analysis is an algorithm that can calculate metric values in objects with an irregular geometry. Since the treetops have an irregular geometric form, the fractal analysis tool is an appropriate tool to get the metric measurements of it.

Finally, centroids were on the centre of trees. The centroids generation is a way to calculate distance between trees and check for missing trees. The distance between centroids is calculated to obtain the distance between trees. If a centroid, has expected with centroids generation is missing, on the tree is considered missing for that site and it is counted.

This new plugin is a valuable tool which allowed to automate several measurements on treetops using GIS analysis tools, considering data acquired by UAV.

UAV APPLICATION FOR FAST PATHFINDING IN ANTARCTIC EXPEDITION

Chi Ma[(1)], Baogang Zhang[(1)], Xiao Cheng[(1)]

[(1)] *College of Global Change and Earth System Science, Beijing Normal University, Beijing, China, machi63269@126.com, zhang_bob@bnu.edu.cn, xcheng@bnu.edu.cn*

Key-Words: UAV, pathfinding, Antarctic replenishment, polar environment, FEIMA

ABSTRACT:

Today for countries without much air support such as China, the replenishments for Antarctic research stations are still mainly depended on ship transportation. Since there is always fast ice, which is a kind of sea ice fastened along the coastline of big ice cap of Antarctica, outside those stations. Supplies should be unloaded from the ship to the vehicles on the fast ice first and then transport to the stations. Because of the fast ice changes every year or every two year and has a very sophisticate growing procedure. Finding a flat and safe route for heavy vehicles on the fast ice is very crucial every time for the replenishment. Usually some small expedition by snowmobile is needed at first to help finding the suitable path. And such pathfinding work is arduous with low efficiency and could be risky on the sea ice of Antarctica. In 2016's Chinese Antarctic Research Expedition, we tried to use a cost-effective, small unmanned aerial vehicle (UAV) to help the pathfinding on the fast ice from Xuelong Vessel (recently the biggest and the most advanced icebreaker ship for polar expedition and relative researches of China) to Zhongshan Station (a research station located in east Antarctica) . In this case 3 successful flights were made when the vessel breaking into the fast ice region. Over 200 overlapping, geo-tagged images were collected in December 3rd, 2016. The images covered an area of the fast ice about 1km wide and 15km far from the vessel to the station with a 10cm ground resolution. It took us about 30 minutes for preparing the flight, 2 hours for flying and 6 hours for generating the DOM and DSM data. In contrast of the satellite image and field expedition by snowmobile, UAV can provide the real-time geo-tagged images for the region of interest and generate the DOM and DSM with higher resolution. Base on the DOM and DSM data it is very clear to find an optimal path for heavy vehicles on the sea ice, much more efficient than the tradition snowmobile way. On the other hand, because the fast ice changes very fast, until now there is little high resolution data for fast ice region. The data we collected has also been pushed to the researchers focused on the sea ice studies and hope it will be helpful for them to understand the growing of the fast ice. The type of the UAV we used is FEIMA F1000 which is developed and manufactured by the FEIMA corp. of China. This UAV is a fixed-wing type with 1.8m wingspan, hand launched and parachute retrieval. It is designed for real-time high resolution image collection and focus on ease of use, transportability and maintainability. Only one person is enough for conducting the flight since it does not need much operation during the flight. So generally, we think that this kind of small and fast respond UAV is a new and cost-effective way for jobs which need the real-time data with high resolution.

PRECISION ENGINEERING FOR GULLY EROSION CONTROL WITHIN THE HUMID TROPICS OF NIGERIA: A REMOTE SENSING APPROACH

Luke Uzoigwe [1], Stanley Maduakolam [2]

[1] Imo State University Owerri, Nigeria, luzoigwe@yahoo.com
[2] Loraj Consortium, Nigeria, maduakolam.stanley@gmail.com

Key-Words: Watershed Characteristics, Precision Engineering, Ortho-photo, Terrestrial Image, Gully Erosion, NEWMAP.

ABSTRACT:

For decades, gully erosion is causing serious environment problems with adverse effect on lives and properties. The huge financial involvements involved in carrying out the required precision engineering application in complex and complicated gully erosion control, surpass allocations meant for wards, local and state government levels. The Federal Government of Nigeria (FGoN), International Development Association such as the World Bank (WB) and Food & Agricultural Organization (FAO) of the United Nations (UN) under the Nigeria Erosion and Watershed Management Project (NEWMAP) decided to jointly seek precise engineering measures to address the complicated and complex issues of gully erosion. For precise and holistic engineering measures for gully erosion control, adequate watershed management involving the processes of guiding and organizing land and other resources usage play a major role. Efficient data acquisition and mapping of precise information, contribute significantly in decision making and proper planning scenarios. Holistic mitigation measures at the Urualla Gully Erosion Site was designed with the aid of remote sensing applications involving spots heights of x, y, z positions (i.e. northing, easting and elevation), ortho-photos and terrestrial images for best possible solutions. Acquired digital terrain data (x, y, z positions) using Trimble UX5 unmanned aerial vehicle (UAV), were imported into Global Mapper 17.0 GIS software which aided in the delineation of various sub-watersheds and determination of maximum runoff contributing to the gully. The ortho-photo acquired with the UAV guided in determining the watershed characteristics, the best hydraulics and structural element required based on socio-economic and technical sound options, bearing in mind precision of such structural elements. The resulted images from the ortho-photo, acquired at a height of 75 m to 750 m has spatial resolution of 0.024 m to 0.24 m. Based on the hydrological findings, the estimated peak discharges generated for the sub-watershed for 25-year return period ranged from 0.43 m3/s to 63.14 m3/s; 0.49 m3/s to 71.99 m3/s for 50-year return period and 0.54 m3/s to 79.81 m3/s for 100-year return period.

CHANGE ASSESSMENT OF THE DOURO SAND SPIT USING FIXED WING UAVS

José A. Gonçalves[(1)] , Joaquim J. Sousa[(2, 3)], Renato Henriques[(4)]

[(1)] *University of Porto, Science Faculty, R. Campo Alegre, 4169-007 Porto, Portugal, jagoncal@fc.up.pt*
[(2)] *University of Trás-os-Montes e Alto Douro, Quinta de Prados, 5000 Vila Real, jjsousa@utad.pt*
[(3)] *INESC Technology and Science (INESC-TEC), 4200-465 Porto, Portugal,*
[(4)] *University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal, rhenriques@dct.uminho.pt*

Key-Words: Coast; Change Detection; High resolution; DSM; Accuracy.

ABSTRACT:

Coastal zones are affected by natural processes of sand transportation, which give rise to topograhic changes in beaches and dunes. The change assessment can be done by comparing digital surface models of different epochs. Airborne laser scanning and conventional photogrammetry can provide these data but are only affordable for relatively large areas. Change assessment and quantification in beaches of relatively small size (e.g. 1 km2) can be done with digital surface models (DSM) derived from imagery acquired with UAVs.

This paper describes a study that has been carried out in the Douro river sand spit. This area is known for its frequent changes, due to the natural action of the sea and the river flow, and now also due to the recent construction of a jetty. Several flights have been carried from July 2013 to March 2017, using Sensefly Swinglet and eBee UAVs, for acquisition of images with 5 cm ground sampling distance. Images were oriented with signalised ground control points, surveyed with dual frequency GNSS, and an accuracy better than 2 cm. DSMs were derived with a 20 cm resolution, which was found to be appropriate to describe the sand surface with very good detail. The cameras used are compact cameras, with moving parts, and normally a camera self calibration is considered in the orientation. In order to control the vertical accuracy of the resulting DSM, and avoid possible deformations in areas with poor coverage of GCPs, many vertical check points were also surveyed, normally around one hundred, well distributed over the area. These points are not marked and can be surveyed very fast. In all cases vertical accuracy was found to be below 5 cm (root mean square error), without systematic trends.

The comparison of the DSMs from 3 different epochs provided important results about the changes that are taking place, which are essentially an increase in sand volume in the sea side. This was especially large between flights 1 and 2 and slightly less between flights 2 and 3. Comparisons were made by assessing the positional difference between contours of the same height (2 meters), and mainly by subtracting the DSM. This also allows for the calculation of volume differences between surveys. The method proved to be very efficient, allowing to complement and replace other surveying methods that had been done for longer periods. The main limitation is the wind, which in the Portuguese Atlantic coast are frequently strong. Images also should be acquired preferably in low tide. Days with full cloud cover are also preferable, because the sun shine can originate saturated images of the sand, making the automatic stereo matching more difficult.

USING A UAS FOR ENVIRONMENTAL MONITORING OF THE MARINE ENVIRONMENT

Steven Lloyd [(1)], Paul Lepper [(2)], Simon Pomeroy [(3)]

[(1)] Loughborough University, Wolfson School of Mechanical, Electrical and Manufacturing Engineering Loughborough University, Leicestershire, UK, LE11 3TU, s.d.lloyd@lboro.ac.uk
[(2)] Loughborough University, Wolfson School of Mechanical, Electrical and Manufacturing Engineering Loughborough University, Leicestershire, UK, LE11 3TU, p.a.lepper@lboro.ac.uk

Key-Words: Wave Monitoring; Unmanned Aerial Systems; Splashdrone; Open Source Platform; Remote Sensing; Environmental Monitoring;

ABSTRACT:

Environmental monitoring generates data allowing decisions to be made regarding the potential impacts human activities may have on the natural environment. Environmental monitoring can be achieved in-situ, using human operators to collect samples/data, automated sampling equipment which can be left on site to collect samples/data over time; or by the use of aerial systems, such as satellites and aircraft, for remote sensing. The latter group is often quicker than surface based assessment and allows much larger areas to be monitored but often at higher cost and higher safety risk. A rapidly developing area in environmental monitoring utilises Unmanned Aerial Systems (UAS), which are versatile, customisable, readily available, safer and are often seen as cost effective solution.

Previous research by the authors into using a UAS for environmental monitoring of the marine environment has been concerned with the acquisition of underwater acoustics [1]. Under real world conditions where the UAS is on the surface of the water and is logging the response from the attached acoustic system, the UAS is free to move with the ocean waves and current. During this time, the flight controllers' on-board sensors are still producing data. The data includes acceleration, angular velocity, heading and pressure from the inertial measurement unit (IMU), alongside the latitude, longitude, time and speed over the ground from the global positioning system (GPS). This data, for our application, can be used to determine when wave height exceeds safe heights to carry on with an acoustic survey, due to an increased chance of capsizing. It is also important for the UAS to take-off from the crest of a wave, to avoid the UAS propellers contacting the waves face or rear during take off and causing it to capsize. Additionally it the data can also stop the UAS capsizing when on a breaking wave by starting up motors on one side to keep it going beyond an angle of 450. Beyond the scope of this research, a UAS based system could be used after an earthquake to detect if a tsunami is present and for short term environmental monitoring of the marine environment.

Current marine sensor systems, such as wave buoys and weather station buoys already use sensors seen in UAS for measuring significant wave height, wave direction, wave energy spectra [2], [3]. Wave buoy systems are used for high resolution data on small spatial scales, and are moored in order to keep them close to their original deployment position. Deployment of these devices requires the use of large ocean vessels to transport them to site, and tow boats for positioning. These devices are made for long term environmental monitoring, as they are slow and expensive to deploy and retrieve.

An alternative to wave buoys is wave radar. This device uses high frequency radio waves for detection, and can measure significant wave height, current and wind speed. Wave currents, wave heights and wave direction can be detected up to 200 km away from the shoreline [4], [5], and large spatial areas can be covered in a small time frame. This coverage comes at the expense of resolution; resolutions of 2 km are common, depending on the spatial range required. These systems require receive and transmit antennas on a

coastline, requiring transport and setup at site. The receivers and transmitters are vulnerable to vandalism and tampering due to their set up location.

The use of a UAS for the short term monitoring of the ocean, would provide in-situ, high resolution data, while being able to rapidly deploy numerous times at multiple locations. The UAS also has the ability to self-deploy and self-retrieve, reducing transport and deployment costs significantly compared currently methods. The system is highly reconfigurable, and with the addition of sensors such as air speed, temperature and salinity sensors, further information about the local environment the UAS is in can be obtained. A waterproof detachable data acquisition prototype system using a National Instruments MyRIO has been developed. The system attaches to a waterproof UAV known as the Splashdrone, which can be autonomously remotely flown to station, where on board sensors can gather data from an open source flight controller platform, known as the Pixhawk 2.0, which the MyRIO logs. The UAS can be deployed until its battery power runs low or it has completed a time dependent mission. The current state of research for using a UAS for environmental monitoring of the marine environment will be presented. This will include details of hardware and software used for the data acquisition system, as well as the current evaluation of system performance.

References:

[1] S. Lloyd, P. Lepper, and S. Pomeroy, 'Evaluation of UAVs as an underwater acoustics sensor deployment platform', *Int. J. Remote Sens.*, pp. 1–10, Nov. 2016.

[2] 'Glossary | Environment, land and water | Queensland Government'. [Online]. Available: https://www.qld.gov.au/environment/coasts-waterways/beach/waves-glossary/#wave-buoy. [Accessed: 18-May-2017].

[3] National Oceanic and Atmospheric Administration, 'NDBC Moored Buoy Program'. [Online]. Available: http://www.ndbc.noaa.gov/mooredbuoy.shtml. [Accessed: 19-May-2017].

[4] 'CODAR Ocean Sensors - Products - The SeaSonde®'. [Online]. Available: http://www.codar.com/SeaSonde.shtml. [Accessed: 19-May-2017].

[5] 'WERA | high-quality Remote Ocean Sensing System - Helzel Messtechnik GmbH'. [Online]. Available: http://www.helzel.com/de/6035-WERA-Remote-Ocean-Sensing. [Accessed: 19-May-2017].

TOWARDS AN UNMANNED SYSTEM OPTIMIZED FOR INVASIVE PLANT SPECIES MAPPING

Petr Dvořák(1) , Tomáš Bartaloš(2), Josef Brůna(3), Michaela Vítková(3) & Jana Müllerová(3)

(1) Brno University of Technology, Institute of Aerospace Engineering, Technická 2, Brno, Czech Republic, dvorak.p@fme.vutbr.cz
(2) GISAT Ltd., Milady Horákové 57, Prague, Czech Republic, tomas.bartalos@gisat.cz
(3) Institute of Botany CAS, Zámek 1, Průhonice, Czech Republic, (jana.mullerova, michaela.vitkova, josef.bruna)@ibot.cas.cz

Key-Words: Invasive species; Mapping; Unmanned aircraft; Spectral and spatial resolution; Classification

ABSTRACT:

Invasive plant species represent a serious threat to both biodiversity and modern landscape, can cause damage to human health and have serious socioeconomic consequences. Such species spread rapidly, outcompete native flora and their eradication is problematic. New methods enabling fast and efficient monitoring are urgently needed for their successful control. Remote sensing can improve early detection of invading plants and make their management more efficient and less expensive. In an ongoing project, we develop innovative methods of mapping selected invasive plant species using purposely designed unmanned aircraft (UAV). Our aim is to establish fast, repeatable and efficient computer-assisted method of timely monitoring, reducing the costs of extensive field campaigns.

Core element of the project is an unmanned aircraft capable of mapping potentially infested areas. Over the past three years we have developed and field-tested a number of platforms equipped with various cameras and sensors. Based on extensive field tests, classification results and operational experience with various settings, we present a platform optimized for invasive species mapping. We discuss aerodynamic tailoring of the airframe, the powertrain selection and open-source autopilot system tuning. Selection of cameras and spectral filtering is covered in detail, as this forms one of the most important aspects of target detection success. Furthermore, we deal with image georeferencing and related methods to improve the geometric and positional accuracy. Mosaicking process is performed by structure from motion approach implemented in Agisoft Photoscan. The developed automated image processing workflow is described in detail. Delivered results – multispectral georeferenced orthomosaics – serve as an input for thematic classification. The resultant unmanned platform and data processing workflow can provide solution for related scientific fields dealing with plant monitoring, such as precision agriculture, forestry and others.

Despite some remaining issues, such as legislative constraints for UAV operation and limited spectral resolution, the technology seems to outperform traditional remote sensing approaches for invasive plant detection, especially in case of targeted small scale monitoring or short phenophase to be covered. The main advantages being their high flexibility and low cost, unmanned vehicles are here to acquire information in a timely manner and therefore enable efficient eradication of undesirable alien plant invasions.

HABITAT EXTENT AND CONDITION ASSESSMENT USING MULTISPECTRAL REMOTELY PILOTED AIRCRAFT SYSTEM IMAGERY IN THE NW MOUNTAINS OF GALICIA (NW SPAIN)

Díaz Varela, R.A. (1); Hinojo Sánchez, B. (2); Rubinos Román, M. (3); Calvo Iglesias, S. (4) & Díaz Varela, E. (5)

(1) Universidade de Santiago de Compostela, Dep. de Botánica, GI-1809BIOAPLIC. Escola Politécnica Superior. Rúa Benigno Ledo s/n, 27002 Lugo. Spain. ramon.diaz@usc.es

(2) 3edata. Centro de Iniciativas Empresariais. Fundación CEL. O Palomar s/n, 27004 Lugo. Spain. boris.hinojo@3edata.es

(3) 3edata. Centro de Iniciativas Empresariais. Fundación CEL. O Palomar s/n, 27004 Lugo. Spain. marco.rubinos@3edata.es

(4) Universidad de Vigo. Grupo Avaliacion Ambiental Estratexica. Rua alta nº34, 5ºA, 27003 Lugo. Spain. paisaxe@gmail.com

(5) Universidade de Santiago de Compostela, Dep. de Producción Vegetal y Proyectos de Ingeniería, GI-1899ECOAGRASOC. Escola Politécnica Superior. Rúa Benigno Ledo s/n, 27002 Lugo Spain. emilio.diaz@usc.es

Key-Words: RPAS; Habitat conservation; Natura 2000; Multispectral imagery; vegetation indices; GEOBIA; wet heathland and bog mosaics; NW Iberian Peninsula

ABSTRACT:

Sustainable management of mountain wetlands with high biodiversity value, like blanket/raised bogs and wet heathlands habitats considered of priority interest by the EU Council Directive 92/43/EEC, requires methods for the capture of key information on their conservation status. According the abovementioned EU regulation, member states are committed to report habitat condition including an inventory of the extent and location of the habitat types, structure and functions, as well as range and future prospects.

The conservation state of the mosaics of wet heathland and bogs relies on a delicate balance of the management regimes, particularly of cattle grazing and wood biomass control. This balance is also affected by the singularity of the biogeographic context, as these mountains set the southern limit of distribution in Europe of habitats such as blanket bogs. Therefore, they are particularly sensitive to the interaction of driving factors at local level, such as land cover and management change, and global level within the current climatic change dynamics.

Within this framework, effective conservation of these complex habitats mosaics requires detailed spatially-explicit knowledge of spatial pattern and functions to effectively design protection and management measures. This information should also be generated is such a way to enable an easy integration of both the landscape scale, i.e. taking into account the composition and configuration of the landscape mosaic as well as the habitat scale, with reference to the internal structure of the vegetation at each habitat patch. Frequently the conservation assessment and monitoring is based in the evaluation of habitat extent and its dynamics, using remote sensing for the generation of habitat maps. Despite of their interest and utility, the development of tools aiming specifically at the study of habitat internal structure and functions are far rarer, particularly at very detailed scale.

In this context, the information provided by multispectral sensors on board Remotely Piloted Aircraft Systems (RPAS) emerged as a flexible and cost effective alternative for remote sensing environmental survey with an unprecedented spatial resolution. They combine the advantages of the traditional remote sensing exhaustive

mapping and the level of detail reached by fieldwork, filling in the scale gap between field-based observations and full-scale airborne or satellite observations.

In this work, we present an example of applying multi-scale methodologies for the analysis and characterization of habitats mosaics structure and function in wet heathland and blanket bog mosaics in the context of a Natura 2000 site located in the Northern Mountains of Galicia (NW Spain) (Figure 1). We based our analysis in data of ultra-high resolution multispectral imagery in the visible and infrared spectrum acquired by a RPAS.

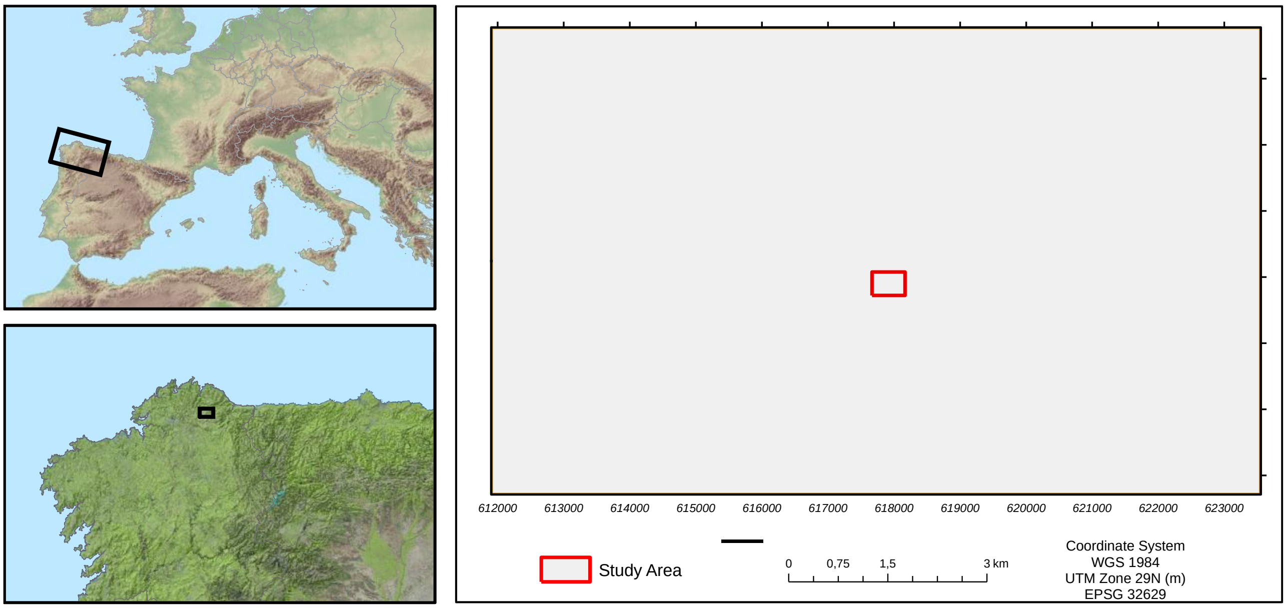


Figure 1. Study area. Source maps: CNIG-IGN, EEA

A collection of 203 aerial images (date of flight 20/06/2016) was acquired by a compact MicaSense RedEdge multispectral snap-shot camera (MicaSense, Inc.) with five narrow spectral bands ranging the visible-infrared spectrum (namely blue, green, red, red edge and near infrared) and 16-bit radiometric resolution. Images were spectrally calibrated against a calibrated panel with values around 70 % of diffuse reflectance in the visible-infrared spectrum. The airborne campaign was conducted using a vertical take-off and landing (VTOL) RPAS quadrocopter operated by 3eData Ingeniería Ambiental S.L. A VTOL quadracopter was particularly suited for this study due to the presence of windfarms and other obstacles in the surroundings of the study area that could have hampered the landing of fixed wing RPAS. Flight plan was set as a single grid with a > 75% and > 80% across and along track overlap respectively and a flight altitude of 115 m above the ground surface operated in VLOS (Visual Line Of Sight), rendering an image footprint of around 109 × 82 m. In order to obtain an accurate georeferencing, a set of 7 ground control point (GCP) were distributed across the flight area and their XYZ coordinates were measured with centimetre-accurate position by using an RTK GNSS.

Images were processed using SfM (Structure from Motion) image reconstruction techniques with the software Pix4D Mapper Pro (Pix4D SA Switzerland). A total of 199 out of the 203 original images were used for the generation of a 1.68×106 XYZ point cloud, an orthomosaic and a DSM, both with a spatial resolution of 8.5 cm/pixel covering an area of 10 ha approximately. The RMSE (Root Mean Square Error) in georeferencing was 2.84, 3.46 and 12.44 cm in XYZ axis respectively.

Geographical object-based image analysis (GEOBIA) automatic classification was done to discriminate vegetation types with different implication in habitat conservation and management. Single band spectral response and vegetation indices (NDVI) along with multiscale spatial pattern were used for the discrimination of vegetation types based on the integration of machine learning classification and decision rules were. In particular, four vegetation classes were assessed, namely woody vegetation (scrub plants higher than 10 cm), bog herbaceous vegetation, non-bog herbaceous vegetation (as part of wet heathland vegetation mosaics) and areas with scarce or no vegetation (rocky habitats and areas of bare ground). Results of automatic classification were validated against reference field data of vegetation coverage.

In addition, a collection of vegetation indices such as the above mentioned NDVI, along with other focused on pigment detection like TCARI, MCARI or other designed for soil background effect correction like the OSAVI, were also used for the assessment of habitat condition and functioning.

Results obtained (Figure 2) allowed the automatic discrimination of habitats with different management requirements such as wet heathlands and blanket bogs at a detailed scale. Classification of vegetation types reached values of overall accuracy higher that 80 %, with a substantial agreement with reference data according the kappa values. Even though the method discriminated effectively bog and non-bog herbaceous vegetation, higher errors were recorded in the classes scrub and bare ground. In the two latter cases, que frequency of small patches might have hampered the discrimination of the classes, suggesting the convenience of higher spatial resolution imagery.

Vegetation indices allowed the detection of clear differences in the functioning of the habitats in the study area for the phenological stage at the image acquisition data, showing a clear contrast between the scrub, bog and non-bog vegetation greenness and pigment activity.

Despite of some misclassifications, the ultra-high resolution imagery allowed in general a detailed discrimination of the vegetation types of the area, despite of their complex spatial pattern with the fine-scale mosaics and transitions that are difficult to differentiate using lower resolution datasets. The information supplied contributes efficiently to the conservation of these habitats and to the optimization of the grazing management and the detection of threats. Hence, the precise discrimination between vegetation types with different productivity, vulnerability and resilience against animal trampling (as bog and non-bog vegetation) is a key issue for the design and regulation of grazing pressures. Also, the calculation of the relative scrub density could be a good indicator for the diagnosis of over- or under-grazing of bog and heath mosaics while the detection of erosive events might also contribute to the elaboration of sustainable grazing planning. Indices related to greenness and radiation pigment absorption reflect differences of vegetation activity driven by habitat class and/or other environmental controls, such as altitude or terrain. This information contributes to a better knowledge of the habitat functional traits and to the design of conservation strategies in the current scenario of global change.

Further work is focused on the improvement of the image quality and calibration along with the improvement of classification performance by the integration of higher resolution imagery and 3d point clouds. Ongoing additional field and airborne campaigns will also contribute to the knowledge of phenological traits by means of multi-seasonal vegetation indices analyses.

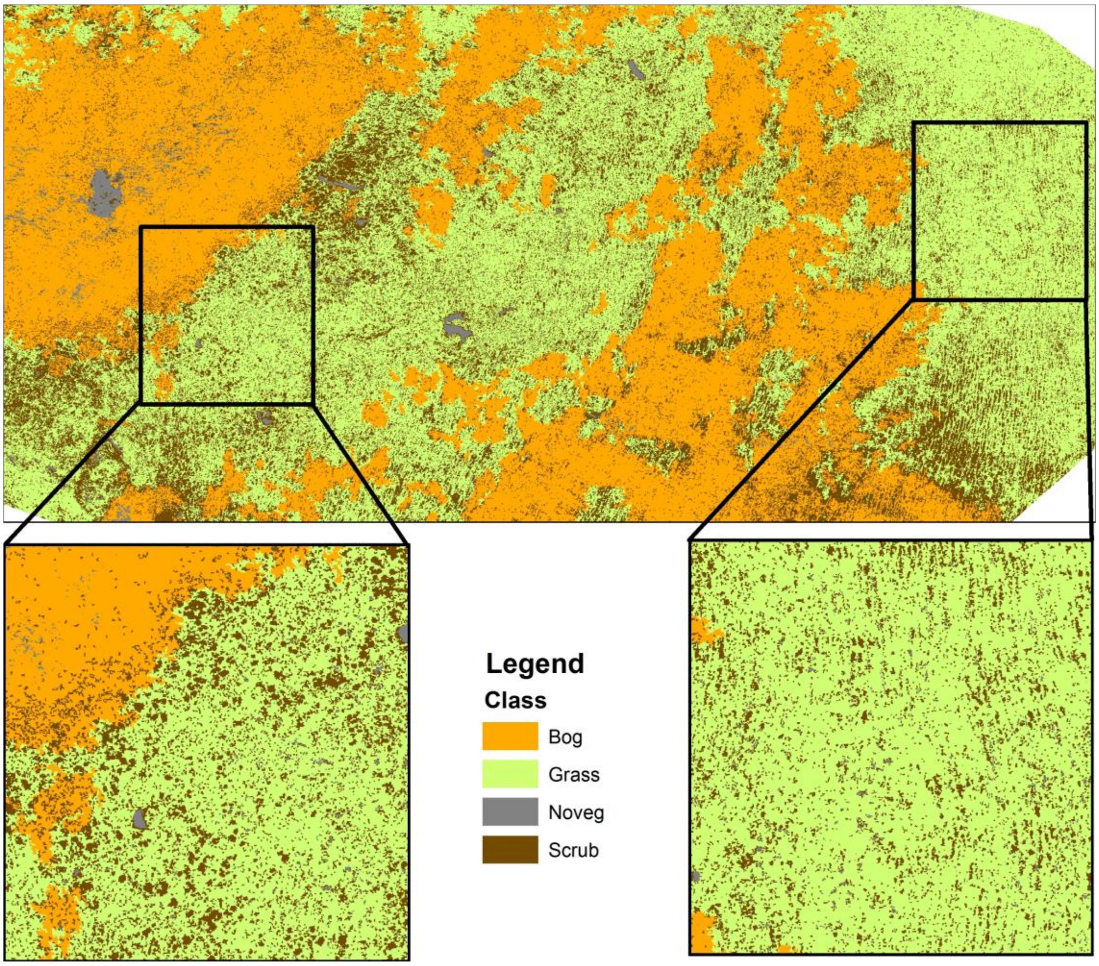


Figure 2. Overall view of the vegetation classification and details of two sections of the study area

TARGET INFLUENCE IN GROUND CONTROL POINT IDENTIFICATION USING HIGH RESOLUTION AERIAL IMAGES

Jonáš Hruška(1), Manuel Vasques(1), Luís Pádua(1), Telmo Adão(1, 2), Joaquim J. Sousa(1, 2), António Sousa(1, 2), Emanuel Peres(1, 2), José Alberto Gonçalves(3) and José Manuel Martinho Lourenço(1,4)

(1) University of Trás-os-Montes e Alto Douro, Engineering Department, 5000-801 Vila Real, Portugal, , jonash@utad.pt, scp_manuel@hotmail.com, luispadua@utad.pt

(2) INESC Technology and Science (INESC-TEC), 4200-465 Porto, Portugal, telmoadao@utad.pt, jjsousa@utad.pt, amrs@utad.pt, eperes@utad.pt

(3)Interdisciplinary Centre for Marine and Environmental Research (CIIMAR) and University of Porto, 4450-208 Matosinhos, Portugal, jagoncal@fc.up.pt

(4) CEMMPRE - Centre for Mechanical Engineering, Materials and Processes, University of Coimbra, 3030-788 Coimbra, Portugal, martinho@utad.pt

Key-Words: ground control points; aerial images; UAS; orthoimages.

ABSTRACT:

Nowadays, the use of non-metric camera mounted on an Unmanned Aerial Vehicle (UAV) has become a very popular and cheap solution to collect geospatial data. Despite their great versatility, most of the UAVs integrate a Global Navigation Satellite System (GNSS) receiver to deliver position and orientation parameters. However, those embedded GNSS receivers consist in a single-frequency receiver, whose accuracy in the positioning of the acquired images is, in most cases, of a few meters. In practice, an UAV orthoimage produced without any registration is affected by an error of several meters, which may not be acceptable for further geospatial analysis over time. In order to achieve high positioning to ensure accuracy of photogrammetric products, like orthoimages, a number of ground control points (GCPs) are often required. GPCs may consist on natural marks, already existing on the ground, or artificial (user- deployed) marks.

From our knowledge, currently there are no studies that systematize the type of mark to be used as ground control point, depending on flight parameters and sensor type, but also on the target characteristics (colour, material, size and shape, among others). For example, the flight altitude limits the detection of the mark on the image and, consequently, influences the accuracy of its identification. Fig. 1 presents a set of the evaluated targets.

Figure 1. Aerial image of different used targets.

Aknowledgments:

This work was financed by the European Regional Development Fund (ERDF) through the Operational Programme for Competitiveness and Internationalisation - COMPETE 2020 under the PORTUGAL 2020 Partnership Agreement, and through the Portuguese National Innovation Agency (ANI) as a part of project "PARRA - Plataforma integrAda de monitoRização e avaliação da doença da flavescência douRada na vinhA" (Nº 3447) and ERDF and North 2020 – North Regional Operational Program, as part of project "INNOVINE&WINE – Vineyard and Wine Innovation Platform" (NORTE-01-0145-FEDER-000038).

CHARTS FOR DETERMINING FLIGHT HEIGHT AND SPEED FOR UAV PHOTOGRAMMETRIC FOREST MAPPING

Karel Kuželka[(1)], Peter Surový[(2)]

[(1)] Czech University of Life Sciences, Prague; Kamýcká 129, Praha – Suchdol, 165 21; kuzelka@fld.czu.cz

[(2)] Czech University of Life Sciences, Prague; Kamýcká 129, Praha – Suchdol, 165 21; surovy@fld.czu.cz

Key-Words: Unmanned aerial vehicle; Photogrammetry; Forestry; Flight parameters

ABSTRACT:

The quality of image material in unmanned aerial vehicle (UAV) aided photographic mapping is determined not exclusively by the characteristics of the employed camera and optical quality of lens. Choosing the appropriate flight parameters, namely flight height and speed, with respect to camera sensor size and resolution, lens characteristics and mapped scene parameters is essential in the process of assessing photography sequences of demanded quality, available for deriving secondary products as orthomosaics or 3D point clouds. The flight height depends on a user-specific parameter: the spatial resolution. With a given spatial resolution required, the flight height is determined by technical parameters of utilized sensing device: the resolution of the sensor and the field of view of the camera.

Determining the optimal flight speed is a more complex task. The demand of maximum quality of derived outputs secured by slow flight is in conflict with economic interests embodying effective exploitation of energy sources and time capacity. Excessive flight speed can result in a motion blur in the photographs accordingly to shutter speed, which depends on a complex of parameters as actual light conditions, sensor quality, ISO speed and aperture setting. However, in most cases, flight speed is limited by a requirement for successful photo processing – the minimum overlay of subsequent images. The requirement of minimum overlay results in a flight speed limit as a function of flight height, sensor size and lens focal length.

Effective mapping of forest stands is contingent on successful recording of terrain surface in canopy gaps. To reconstruct the terrain surface, identical features must be detected in minimum three photos acquired from different angles. For forest mapping, flight speed is derived from flight height, canopy height and the size of canopy gaps.

We derived a set of charts allowing assessing flight height appropriate for required spatial resolution in accordance with sensor resolution, sensor size and aspect ratio and lens focal length. Another set of charts allows assessing flight speed based on flight height and camera parameters. Special flight-speed-planning charts for forest stands incorporate also parameters of forest structure. The flight parameters as result of mentioned input variables can be also derived using our interactive tool.

ACCURACY ASSESSMENT OF POINT CLOUDS FROM LIDAR AND IMAGE MATCHING ACQUIRED WITH THE UAS PLATFORM

Salach A. [(1)], Bakuła K. [(1)], Pilarska M. [(1)], Górski K. [(1)], Ostrowski W. [(1)]

[(1)] Warsaw University of Technology, Faculty of Geodesy and Cartography,
Department of Photogrammetry, Remote Sensing and Spatial Information Systems, Warsaw, Poland
(adam.salach, krzysztof.bakula, magdalena.pilarska, konrad.gorski, wojciech.ostrowski)@pw.edu.pl

Key-Words: LiDAR, UAV, structure-from-motion, photogrammetry, image-matching, vertical error, accuracy

ABSTRACT:

In the last decade, there was a significant development in using photogrammetric techniques based on images from Unmanned Aerial Vehicles (UAV) for generating digital elevation models, including surface models and filtered digital terrain models. Structure-from-motion algorithms deliver point clouds which are characterized by a high spatial resolution. The biggest disadvantage of such point clouds is the vegetation influence on the vertical accuracy of the derived digital terrain model. In the last years ultralight laser scanners, which can be mounted on UAVs, have been developed. They are able to provide elevation data not influenced much by vegetation and they deliver initial data to digital terrain models describing bare ground in a more accurate manner.

In this paper, the results of the experiment about the vertical accuracy of the generated elevation models were assessed. The generated models were based on two techniques: LiDAR and image-matching, as mentioned above. The data were acquired using an ultralight laser scanner dedicated to UAV platforms and an RGB digital camera. The vertical error of digital terrain models was evaluated on the basis of the surveying data collected in a field. The data were acquired during summer for in a corridor flight mission over levees and their surroundings. The test area was covered by high mixed vegetation, agricultural plants, roads, bushes and trees.

The experiment results showed unequivocally that the terrain models obtained with LiDAR technology are more accurate. Thus, in the next part of the experiment an attempt assessing the accuracy and possibilities of penetration of the point cloud from the image-based approach referring to various land cover was conducted. In this comparison, different methods of point cloud filtration were tested and compared to each other. Additionally, the vertical accuracy of the ground filtration was evaluated for uncovered and vegetation areas separately providing information about the influence of vegetation height on the results of bare ground extraction. Within the experiment, digital surface models were also compared. All of the results were used in order to draw conclusions about the application opportunities of digital photogrammetry in generating digital elevation models as low-cost technology in the rapidly developing UAV market.

SMART COVERAGE PATH PLANNING: ENERGY EFFICIENCY IN SMALL UNMANNED AERIAL VEHICLES SYSTEMS (S-UAVS)

Mohamed Dahman (1) , Israel Quintanilla (2), Naoufal Raissouni (1) , Pablo Morcillo (2) , Debora Robles (2) and Samir El Adib (1)

(1) RSAID Laboratory, National School for Applied Sciences of Tetuan, University of Abdelmalek Essaadi, Mhaneech II. B.P. 2222, 93000 Tetuan, Morocco, dahman10.med@gmail.com, nraissouni@uae.ma and adibsamir@gmail.com

(2) Dept. of Cartographic Engineering, Geodesy and Photogrammetry, Polytechnic University of Valencia, Edif. 7F. Camino de Vera s/n, 46022 Valencia, Spain, iquinta@cgf.upv.es, pabmorpa@etsid.upv.es and derobpe@gmail.com

Key-Words: S-UAVS, Energy, Battery, CPP, Digital Camera, Spatial;

ABSTRACT:

The use of Unmanned Aerial Vehicles Systems (UAVS) is predicted to grow significantly. Not only for military and for surveillance applications, but also in the public sector, gaining interest for agricultural, forest management, search and rescue purposes. Most traditional remote platforms are not suitable in the above-mentioned applications given their expensive price, low temporal and spatial resolutions. Rotatory or fixed wing Small UAVS (S-UAVS) provide us low-cost and very high temporal and spatial resolutions; The problem faced is the battery power autonomy. This research focus in finding the Coverage Path Planning (CPP) for Photogrammetry that reduces S-UAVS energy consumption, having an impact in reducing the amount of batteries used, as well as guaranteeing a desired spatial resolution. The type of S-UAVS used has a multicopter configuration using a vertically mounted digital camera. The study site was located in the Valencian Community, Spain. Our results showed that adjusting the height and CPP, we are capable to ensure the operation satisfactorily providing real-time suggestions to the pilot and aborting the performance when the actual available energy is equal to the energy required to return to home represented in Fig. 1.

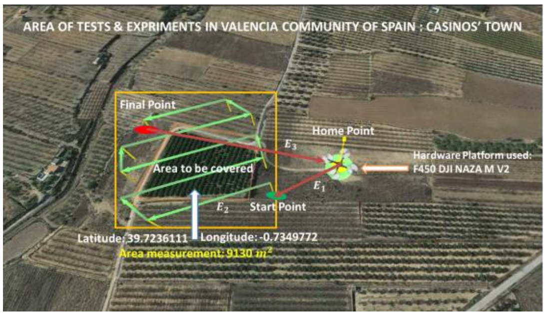


Figure 1. Study site in the Valencian Community of Spain, Energy from home point to start point E_1, Energy of path planning E_2 and Energy to return home E_3

References:

[1] M. J. Cutler, T. W. McLain, R. W. Beard, and B. Capozzi, "Energy harvesting and mission efectiveness for small unmanned aircraft," *AIAA Guid. Navig. Control Conf.*, no. August, pp. 1–13, 2010.

[2] S. Hosseini and M. Mesbahi, "Energy-Aware Aerial Surveillance for a Long-Endurance Solar-Powered Unmanned Aerial Vehicles," *J. Guid. Control. Dyn.*, vol. 39, no. 9, pp. 1980–1993, 2016.

[3] C. Di Franco and G. Buttazzo, "Energy-aware coverage path planning of UAVs," *Proc. - 2015 IEEE Int. Conf. Auton. Robot Syst. Compet. ICARSC 2015*, pp. 111–117, 2015.

DELINEATION OF RILL SOIL EROSION FROM UAV-BORNE REMOTE SENSING DATA

Radek Malinowski [(1)], Goswin Heckrath [(2)]

[(1)] *Space Research Centre, Polish Academy of Sciences, Bartycka 18A, Warsaw 00-716, Poland, rmalinowski@cbk.waw.pl*

[(2)] *Department of Agroecology, Aarhus University, Blichers Allé 20, Postboks 50, DK-8830 Tjele, goswin.heckrath@agro.au.dk*

Key-Words: Curvature; DSM; soil erosion; openness; rank; rill; UAV;

ABSTRACT:

Soil erosion is a very important factor of land degradation and is especially oppressive when it occurs on productively used areas such as agricultural fields. Rill and interrill soil erosion, although less serious and smaller in size then gully erosion, might also bring serious damages. Depending on the time of occurrence it may prevent the field from being used, hampering soil cultivation and resulting in yields reduction. Therefore, reliable information on rill soil erosion of agricultural areas is fundamental for land managers, farmers and decision makers.

The focus of this study is to perform investigation on possibilities of quantitative estimation of rill soil erosion parameters from ultra-high resolution optical data derived from unmanned aerial vehicles (UAV). We claim that UAV-borne remote sensing data provide means for highly detailed analysis of rills properties despite their varying shapes and size ranging from a few up to approximately 50 cm of depth and width. Moreover, UAV remote sensing technology enables survey of extensive fields on much smaller effort and cost then field measurement. Considering this the main objective of this work is to derived information on the spatial extent of rill erosion from within the analysed field and to estimate the volume of eroded soil.

The mapping procedure, which is under development, is based on the UAV-derived RGB photographs with ground sample distance ranging between 6 mm and 30 mm, for different study sites, respectively. The analysis is carried out on two study sites located in different parts of Jutland, Denmark and representing different erosion characteristics.

To make the method transferable to other study sites it was decided that only 3D information derived from UAV photographs will be used in the analysis. Application of radiometric information provided by RGB images would make it easier to extract erosion parameters in certain cases. On the other hand, however, the method would become applicable only in situation when exactly the same local conditions are met. This would restrict utilization of this method in locations with different or no vegetation cover, with different soil type and moisture, and varying sun illumination properties (shadows). Therefore, the RGB photographs were used to derive very detailed digital surface models (DSM) which served as input data for further analysis. The DSMs were processed to extract rasters representing various geomorphological surface parameters that include surface curvatures, openness and rank. These rasters provide vital information on the rill characteristics, however, none of them is decisive enough and they had to be combined to derive rill extent. The rasters were used together in the object-based image analysis environment (eCognition). Such approach enables to use values presented by the aforementioned rasters themselves and also information about the spatial context and spatial arrangement of rills (information of rills' neighbourhood). In the used approach a hierarchical analysis was performed consisting of sequence of segmentation and classification steps, where the used surface parameters were thresholded at various levels and in a predefined order. The created ruleset analysed step

by step each input dataset to derive the most informative characteristics of a rill shape and resulted in the extraction of rill erosion extent.

Once the location and extent of erosion was estimated, information about its spatial extent was used to artificially fill in the rills incisions by interpolating elevation values for the filled surface from the elevation of the detected incision edges. In the final step, comparison of the two surfaces, i.e. the initial UAV-derived DSM and the DSM with filled rills, allowed estimation of eroded soil volume.

The applied method provided promising results, nevertheless the forthcoming step of the study will include quantitative validation of the derived rills characteristics that will be performed using field measurement data (real-time kinematic GNSS) and visual interpretation of UAV-borne photographs. The biggest challenge of the study that still need to be addressed is detection of narrow and shallow rills with dimensions of a few centimetres. Another important step of the analysis will include refinement of the erosion extent to exclude from rills incorrectly classified tractor tracks and furrows.

ADAVANTAGES OF USING UAVS DATA TO STUDY ROCKY COASTS GEOMORPHOLOGY: THE CASE STUDY OF THE SÃO PAIO ROCKY LITTORAL, PORTUGAL

Lopes, Mafalda (1), Marques, Miguel (2), Coelho, Cláudia (3), Araújo, Maria Assunção (4), Gomes, Alberto (5),

(1) *Faculdade de Letras da Universidade do Porto, Via Panorâmica, s/n 4150-564 Portugal, mafalda.lopes7@gmail.com*

(2) *Geolevação, geoelevacao@gmail.com*

(3) *Faculdade de Ciências da Universidade do Porto, Rua do Campo Alegre 1021/1055, 4169-007 Portugal, coelho.claudia91@gmail.com*

(4) *Centro de Estudos de Geografia e Ordenamento do Território (FLUP), Via Panorâmica, s/n 4150-564 Portugal, m.a.araujo@netcabo.pt*

(5) *Centro de Estudos de Geografia e Ordenamento do Território (FLUP), Via Panorâmica, s/n 4150-564 Portugal, albgomes@gmail.com*

Key-Words: UAVs; rocky coast; costal geomorphology; geological mapping.

ABSTRACT:

Rocky Coasts comprises about 80% of the coasts of the earth [1]. Along the European oceanic coast, this type of littoral constitutes 1/3 of the coast (about 3666 km) representing approximately 37% of the total length [2]. According to the same authors, 48% of the rocky coasts develop in outcrops of resistant rocks, such as granites and limestone’s. Despite their relevance in quantitative terms, the rocky coasts receive less attention from the scientific community when compared to the sandy coasts. This fact is associated with urban, industrial or recreational uses and pressures [3], and the assumption of high social and economic value for the sandy coasts [4].

The studied area covers the coastal stretch of São Paio at Portugal, located at Vila do Conde municipality, 15 km at north of the Douro River and the city of Porto. It differs from the typical coast of the Porto region, generally low, since it consists of a rocky coastal stretch characterized by two massive granite small hills (Mota hill, north and the Facho hill, in the south), separated by a small beach, called Castros beach [5].

This study presents an integration of classical fieldwork with new technologies into the geomorphological and geological research of rocky coasts, namely by the acquisition and analysis of images captured by autonomous unmanned vehicle (UAV) and further processing of the collected data. From a collection of aerial photographs (5 cm of pixel size), it was made a global orthoimage of the area and produced a digital terrain and a surface model. These data were the basis for the elaboration of detailed geological and geomorphological maps, which are the main results presented.

The specific characteristics of flights with an UAV (low altitude flight) allows images that offer many advantages, such as, excellent resolution, large overlap and reduced execution time [6]. In this survey, it was used a Hexacopter device (± 2700g of weight), class 550 with a controller 3dr APM for Arducopter 3.6 and with a time of operation of 12 - 16min. The image acquisition was performed from an UAV equipped with a conventional Canon Powershot sx260hs (12 megapixels) digital camera whose memory card has an application (CHDK-Canon Hack Development Kit) that allows shooting automatically within a certain time interval set by the user.

In order to improve the quality of the images obtained, the flights were executed on 08/12/2014 and 01/23/2015, days with low cloudiness and during spring low tides, with the objective of shot in detail and

clearly the marine erosion platforms and boulders that are usually covered by the sea. A recent survey and flight was done in April of 2017, in order to evaluate the shore dynamics and changes occurred between 2014-2017. In addition, some control points (marked with red crosses on the terrain surface and in observable positions on the aerial photographs) were also collected using a LEICA SR20 differential GPS. The subsequent tasks to process data in order to match the photos and obtain the respective DTM and DSM are briefly exposed in Fig. 1.

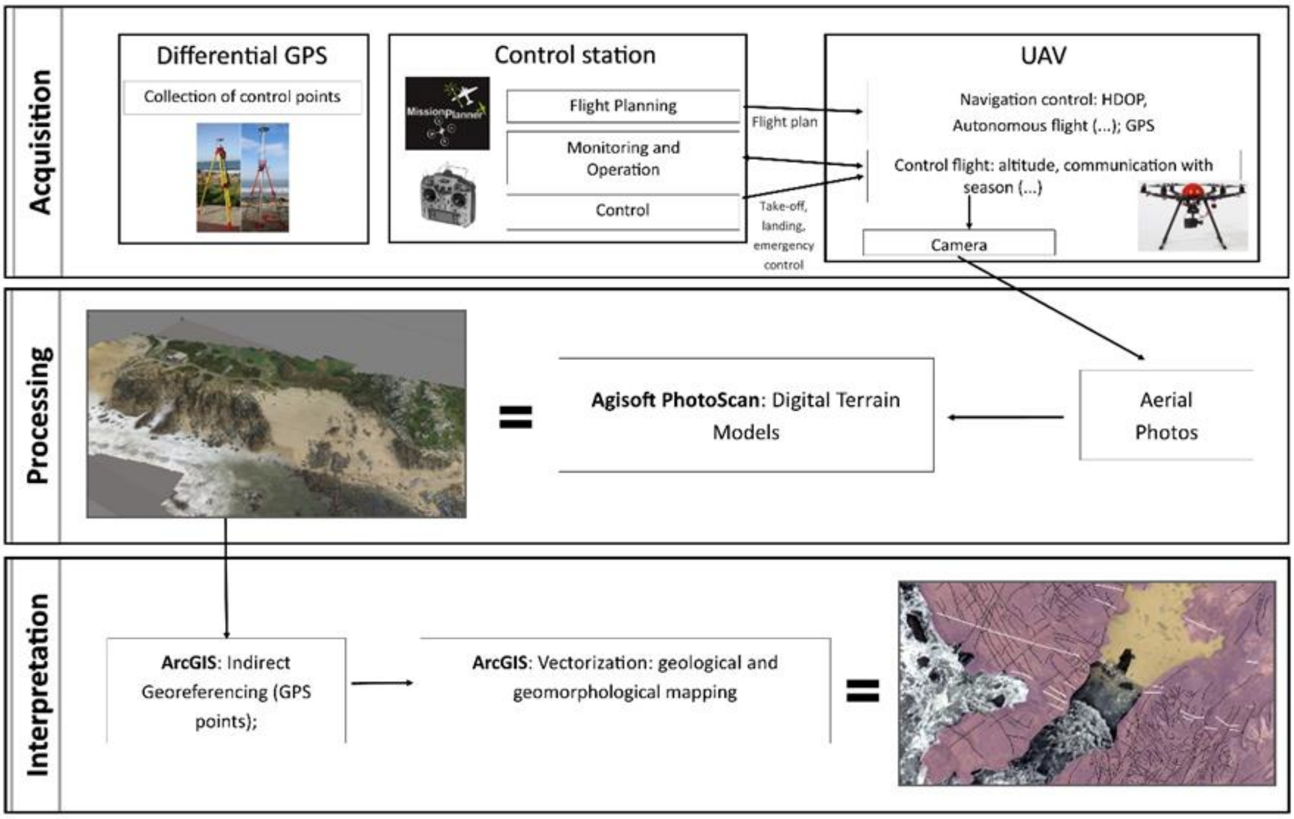


Figure 1. Workflow of the project following the proposals of [7] and [8].

The data vectorization process began with the visual interpretation of the various geological elements according to their characteristics. Considering the contrast of colour in relation to the surrounding rock and the association with very sharp linear forms the veins were distinguished. In addition, the same recognition properties allowed the discontinuities mapping. This mapping is more difficult than the veins, since the contrast of the colour is not so obvious due to the discontinuities reveal a darker colour, a more irregular shape and smaller length and width. In addition to the exposed recognition properties, interpretation was also experimented with changes in the observation scale, mainly in the interpretation of the veins and the discontinuities, in cases in which their continuity was not perceptible.

The global orthoimage allowed the definition of two dominant directions for the veins and discontinuities, NW-SE and NNW-SSE. The veins consists essentially of quartz and feldspar, corresponding to aplite-pegmatite textures, and a few number of uncommon lamprophyres veins. Some veins are rejected by short displacements or appear intermittently, but are clearly rejected. Strike-slips on the reefs are dominantly right. The pixel resolution of 5 centimetres makes it possible to identify the smallest discontinuities, as well as the fine veins. However, the high resolution and the advantage of being able to zoom in on the image sometimes becomes a difficulty, since it is often lost the notion of space and what have been mapped.

Regarding to the area lithology, since we cover the inter-tidal range, the variations of colour and tonality are quite large, which does not allow distinguishing with great clarity the lithological differentiation. The field knowledge acquired from the area reveals that there is only one type of granite with slight textured differences, and a metamorphic rock basement on the southern boundary of the map.

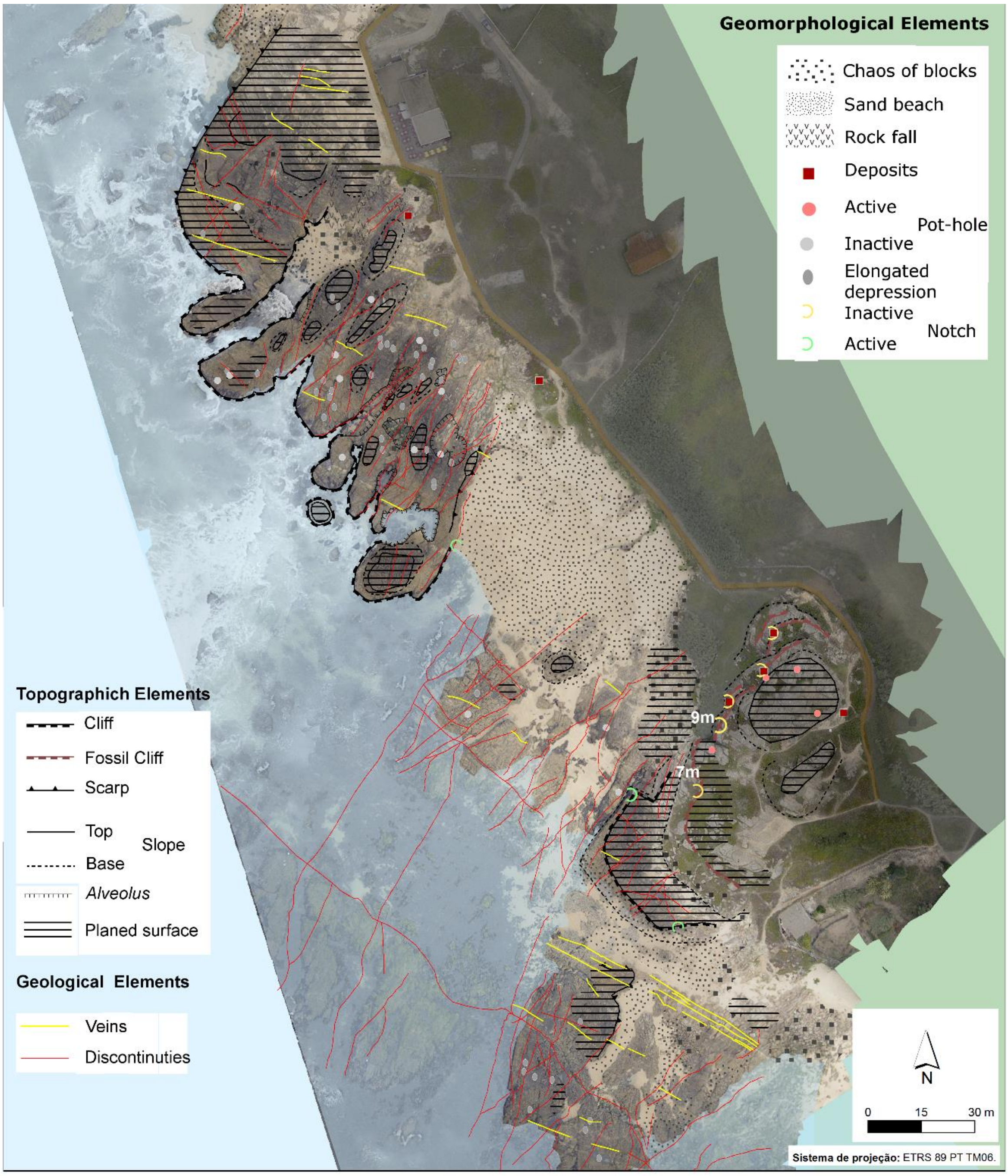


Figure 2. Detailed geomorphological map of the São Paio littoral sector.

Concerning to the geomorphology, the UAV data made it possible to recognize with high detail several coastal forms on the cliffs, on the platforms and at the granite hills that were unknown or badly characterized, giving precision to quantify their morphometric parameters (Fig. 2). Many coastal potholes at different altitudes, elongated topographic depressions and small flat surfaces were identified and mapped. With these new data, it was possible to distinguished clearly four geomorphological sectors that are quite evident on the longitudinal profiles and illustrates the huge altimetry variation of the surface, mainly due to discontinuities explored by the marine erosion.

In conclusion, the quality of the orthoimage obtained by the aerial photographs of the UAV to perform detailed cartography on this rocky coast was excellent. One great advantage comes from the precise and detailed characterization of geological and geomorphological features exposed in this work, such as the diversified veins, cliffs, erosion platforms, notches, coastal boulders, littoral potholes and even old deposits, in addition to the current sediments.

The use of UAVs in comparison with other data acquisition techniques is very advantageous since the costs and time spent in collecting and processing the data are relatively short. Processing images can even be carried out on-site, which allows an immediate result to be visualized and facilitates the correction of errors through repeated flights. Given these characteristics and the improvement of the geological interpretation of the rocky sector of São Paio obtained with these new data, it is assumed that the acquisition of data from this costal environment constitutes an important technique to apply in the studies of rocky coasts, especially for geomorphological studies [9], and possibly also for risk mapping. The flight easiness repetition and speed of data processing makes it accessible tool and very effective in monitoring and managing the rocky coasts.

References:

1. Emery, K.O. & Kuhn, G.G. (1982). Sea cliffs: their processes, profiles, and classification. *Geological in the Society of America Bulletin*. 93, 644–654.

2. Gómez-Pujol, L., Pérez-Alberti, A., Blanco-Chao, R., Costa, S., Neves, M. & Río, Laura Del (2014). The rock coast of continental Europe in the Atlantic. Rock Coast Geomorphology: A Global Synthesis. *Geological Society, Memoirs 2014*, 40, 77-88.

3. Sunamura, T (1992). Introduction. In Geomorphology of rocky coasts. *Wiley*, 1-4

4. Naylor, L.A., Stephenson, W.J. & Trenhaile, A.S. (2010). Rock coast geomorphology: Recent advances and future research directions. *Geomorphology*, 114, 3-11.

5. Araújo, M. A., Teixeira, J., Marques, M. (2014). A área do S. Paio (Labruge, Vila do Conde): desafios científicos e uso de novas tecnologias. *Atas do XIV Congresso Ibérico de Geografia*, 2200-2205.

6. Humphrey, D. (2014). UAV and GIS, an emerging dynamic duo. Available at <*http://www.esri.com/~/media/Files/Pdfs/news/arcuser/0314/uav-and-gis.pdf*>.

7. Sabins, F. (2007). Introduction to concepts and systems In Remote Sensing: Principles and Applications. *Waveland Press*, 2-31.

8. Kaneko, K. & Nohara, S. (2014). Review of Effective Vegetation Mapping Using the UAV (Unmanned Aerial Vehicle) Method. *Journal of Geographic Information System*, 6, 733-742.

9. Pérez-Alberti, A. & Trenhaile, A.S. (2015). An initial evaluation of drone-based monitoring of boulder beaches in Galicia, north-western Spain. *Earth Surface Processes and Landforms*, 40 (1), 105-111.

UAVs DATA FOR MONITORISING RESCUE ARCHAEOLOGICAL EXCAVATIONS: RODO, BISPEIRA 8 AND VAU SITES IN RIBEIRADIO RESERVOIR, VOUGA CATCHMENT (PORTUGAL)

Monteiro Rodrigues, Sérgio(1), Marques, Miguel(2), Gomes, Sérgio(3), Ameijenda Iglésias, Alícia(4), Manzano, Carmen(5), Gomes, Alberto(6),

(1) Centro de Investigação Transdisciplinar «Cultura, Espaço e Memória» (FLUP), Via Panorâmica, s/n 4150-564 Portugal, sergio.fossil@gmail.com

(2) Geolevação, geoelevacao@gmail.com

(3) Centro de Estudos em Arqueologia, Artes e Ciências do Património (CEAACP), Palácio de Sub-Ripas 3000-395 Coimbra, Portugal, sergioalexandregomes@gmail.com

(4) Arqueologia e Património - Ricardo Teixeira & Vítor Fonseca Lda, Rua Chouso 434 4455-804 Matosinhos, Portugal, aameijenda.iglesias@gmail.com

(5) Arqueologia e Património - Ricardo Teixeira & Vítor Fonseca Lda, Rua Chouso 434 4455-804 Matosinhos, Portugal, cmanzano.molina@gmail.com

(6) Centro de Estudos de Geografia e Ordenamento do Território (FLUP), Via Panorâmica, s/n 4150-564 Portugal, albgomes@gmail.com

Key-Words: UAV; archaeological sites; archaeological mapping; archaeological excavations.

ABSTRACT:

Rescue archaeology challenges are current in archaeological research in many ways. The usual short time to develop a fieldwork intervention is one of those challenges, demanding the selection of trained teams, which may answer to the questions raised during the process of excavation. If a well-trained team is important in order to face such questions, one should also highlight the importance of using new recording technologies that could support the team in the interpretation process of the evidences coming from the ground during excavation. One of the strategies that may answer to these challenges is the use of photogrammetric products from aerial photograph using a UAV. This technique allows, as we will see, the production of several photographic records, which may help to characterise and interpret both archaeological and geomorphological realities [1, 2]. The use of these techniques and data not only complement the traditional recording practices as they become useful tools on the way the team may observe the archaeological evidence, challenging the process of gathering and interpreting data.

This paper focus on the case of how such challenges were managed during the intervention on three prehistoric sites – Rôdo, Bispeira 8 and Vau – located at the mid Vouga's valley, which were intervened due the construction of the hydroelectric facilities called "Aproveitamento Hidroelétrico de Ribeiradio-Ermida". This project entailed a dam and a reservoir (located at Sever de Vouga and Oliveira de Frades) which would flood a large area within were located the archaeological sites mentioned above. As the identification of the sites was made during the final works of the dam, there was little time to plan and execute the excavations needed to understand the archaeological sites. Regarding this, there was a concern about the creation of an interdisciplinary team to assure the interpretation of the geomorphological and geoarchaeological dynamics of the sites. At the same time, a challenge to use technology that could speed up the process of gathering and recording the data needed to characterize, understand and interpret the archaeological evidence both during the fieldwork and afterwards on post-excavation research.

The three prehistoric sites – Rôdo, Bispeira 8 and Vau – present stratigraphic levels with remains of human occupation dating from the Late Pleistocene and Holocene [3, 4, 5]. Due the lack of sites of these chronologies in the region, they become a very important source of information to create knowledge about

how prehistoric communities dwelt in this region during these periods. At the same time, regarding its location at the Vouga's valley, these sites are also an important source of data, which may contribute to the understanding of how these sites might have been articulated with other important prehistoric sites from the Portuguese Estremadura and from the Côa Valley. Besides the archaeological relevance of the sites, the archaeological intervention was also an opportunity to gather data regarding the geomorphological dynamics of the Vouga River. Should be noted that these geomorphological data were, in its own terms, elements that would help to understand the archaeological record. In fact, each archaeological site is located at different points of the valley, which means that each one has its own geomorphological specificities requiring different, but articulated, research concerns. This diversity also means that each site carried the possibility to create different points of observation on the geomorphology of the Vouga's valley.

The site of Rôdo is located on a flat surface corresponding broadly to a fluvial terrace, inclined towards the current riverbed of Vouga, encompassing the convex sector of a meander, inserted in the embedded valley of the river. The platform where this site is located results of a long process in which there were contributions from different dynamics: the river incision and the formation of different terrace levels and from slope erosion. Bispeira 8 is located upstream of Rôdo at a higher elevation. At this location, there was no clear vestiges of terraces and, from a geomorphological point of view; it seems that the site was formed only because of slope dynamics. Vau is located at the foot of the slopes of Teixeira's valley, a tributary of Vouga river. The archaeological remains were located at a meander in which a river beach was formed. At this location, the geomorphological context and the dynamics of the site is similar to Rôdo, i.e, the site was formed within the process of the Teixeira's incision and by slope erosion. Even so, as we will present, the archaeological and geomorphological reality observed at Rôdo and Vau have many differences. In fact, these three sites present a geomorphological and geoarchaeological complexity whose recording demanded traditional topographic methods and, at the same time, other technologies – namely high detailed orthoimage for small/medium areas – which could enlarge the observation area and allow its articulation with other points of the valley in order to contextualise local evidence with larger scales of analysis.

During the archaeological intervention there was a conjunction between classical fieldwork and new technologies, which were useful for the excavation record and later research, namely by the acquisition and analysis of images captured by autonomous unmanned vehicle (UAV) and further processing of the collected data. On the field, it was used a Hexacopter device (± 2700g of weight), class 550 with a controller 3dr APM for Arducopter 3.6 and with a time of operation of 12 – 16 min. From a collection of aprox. 600 aerial photographs (5 cm of pixel size), it was made a global orthoimage of the areas, and produced digital surface models and digital terrain models. These data were the basis for mapping the archaeological sites, the archaeological structures, and have detailed geomorphological data to analyse and to interpret the local context, namely by the DTM's. In addition, to refine the altitude data it was used several control points of the excavations sites, which were defined by classical topographic techniques (using a Leica TS02 plus 7" device) and referenced to the national geodetic network.

The image acquisition was performed from the UAV equipped with a conventional Canon Powershot sx260hs (12 megapixels) digital camera whose memory card has an application (CHDK-Canon Hack Development Kit) that allows shooting automatically within a certain time interval set by the user. The global orthoimages became an important support for the further discussion on cabinet after the conclusion of the fieldwork. The specific characteristics of flights with an UAV (low altitude flights) allow having images with many advantages, such as: excellent resolution, large overlap and reduced execution time [6]. In the processing step, the photographs obtained were verified and selected, excluding those that were blurred or captured during take-off and landing. Then, they were processed with Agisoft PhotoScan software, which generates a digital textured surface model from a cloud of points. Firstly, the program aligns the photographs according to common points or points of correspondence that are present in several images, and are invariants to the changes of illumination, to the noise of the image and also performed the basic geometric transformations as: scale, translation and rotation. These points are identified as elements of an object, and therefore the position of each photograph is rectified and the calibration parameters improved [7]. Subsequently, a dense cloud of dots is created by estimating camera positions and photographs.

The third phase was the 3D model creation from the dense cloud of points. The software reconstructs a polygonal and three-dimensional mesh that represents the surface of the study area. Finally, after the 3D model (the geometry) be completed, it was possible to add texture to the surface and generate a global orthoimages of the area. The result of this process consists of a digital surface model georeferenced from the GPS data of the photographs. Finally, the interpretation stage was carried out. Previously, the orthoimage was added to the ArcMap software (ArcGIS) and indirect georeferencing [8] was achieved through control points of the excavation sites. This procedure gave to the orthoimage more spatial precision.

Figure 1. UAV orthoimage showing the clear distinction of the two geoarchaeological units (dot line) and the axe of a surficial debris flow (arrow) affecting some of the top archaeological structures.

Thus, the intertwining of traditional and new recording techniques allowed the creation of products in which global images of the excavation can be observed with detailed recording of the archaeological features (stone structures, for example) and its stratigraphic context. At the same time, these images, by capturing the geomorphological frame of such features, were also useful tools to understand how some of them were preserved or dismantled. By giving these kind of information, these images turned to be also useful tools on the management of the excavation itself. Besides that, these visual products also revealed to be useful elements on post-excavation research, by enabling three-dimensional models that allow developing previous ideas and the emergence of new points of view. Fig. 1 is an example of how orthoimages can be used in order to understand the archaeological record to which can be added information regarding the geomorphological dynamics. In fact, the technique recreates the conditions under which the interdisciplinary dialogue can be developed and, by doing this, it makes possible the creation of new images, which can translate in diverse ways the knowledge produced during the excavations.

Given the advantages of this technology regarding the gathering and interpretation of data during the excavation and after it, and its low budget, it seems that it should be considered on the archaeological interventions.

References:

1. Malinverni, E.S., Conati Barbaro, C., Pierdicca, R., Bozzi, C.A. & Tassetti, A.N. (2014). "UAV surveying for a complete mapping and documentation of archaeological findings. The early neolithic site of Portonovo. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, XLI-B1, 1149-1155.

2. Mouget, A. & Lucet, G. (2014). Photogrammetric archaeological survey with UAV. *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences*, II (5), 251-258.

3. Ameijenda, A., Manzano, C., Oliveira, L. & Gomes, S. (2015). Aproveitamento Hidroelétrico de Ribeiradio-Ermida. Intervenção Vau (Ocorrência Patrimonial Nº 214). *Relatório Final, Matosinhos: Arqueologia e Património Lda.Arqueología e Patrimonio*.

4. Ameijenda, A., Manzano, C. & Gomes, S. (2016). Aproveitamento Hidroelétrico de Ribeiradio-Ermida. Intervenção em Rôdo (Ocorrência Patrimonial 156). *Relatório Final, Matosinhos: Arqueologia e Património Lda.*

5. Costa, B., Manzano; R., Oliveira, M.L., Santo, R. & Gomes, S. (2015). Aproveitamento Hidroelétrico de Ribeiradio-Ermida. Intervenção em Bispeira 8 (Ocorrência Patrimonial 246). *Relatório Final, Matosinhos: Arqueologia e Património Lda.*

6. Humphrey, D. (2014). UAV and GIS, an emerging dynamic duo. Available at <http://www.esri.com/~/media/Files/Pdfs/news/arcuser/0314/uav-and-gis.pdf>.

7. Verhoeven, G., Sevara, C., Karel, W., Ressl, C., Doneus, M. & Briese, C (2013). Undistorting the past: new techniques for orthorectification of archaeological aerial frame imagery. Good Practice in Archaeological Diagnostics. *Springer*, 31-67.

8. Neitzel, F. & Klonowski, J. (2011). Mobile 3D mapping with a low-cost UAV system. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci*., 38, 1-6.

UAVs ORTHOIMAGES FOR IDENTIFYING AN MAPPING GEOMORPHIC INHERITANCE OF THE QUATERNARY GLACIERS AT THE SOAJO-PENEDA MOUNTAIS, PORTUGAL

Silva, António (1), Marques, Miguel (2), Calicis, Eva (3), Martins, Cátia (4), Péres-Alberti, (5), Gomes, Alberto (6),

(1) Faculdade de Letras da Universidade do Porto, Via Panorâmica, s/n 4150-564 Portugal, mafalda.lopes7@gmail.com
(2) Geolevação, geoelevacao@gmail.com
(3) Faculdade de Letras da Universidade do Porto, Via Panorâmica, s/n 4150-564 Portugal, eva_calicis@hotmail.com
(4) Faculdade de Letras da Universidade do Porto, Via Panorâmica, s/n 4150-564 Portugal, catia.martins.geographer.gis@gmail.com
(5) Universidade de Santiago de Compostela, xepalber@gmail.com
(6) Centro de Estudos de Geografia e Ordenamento do Território (FLUP), Via Panorâmica, s/n 4150-564 Portugal, albgomes@gmail.com

Key-Words: UAV; orthoimage; glacial cirques; moraines; erratic blocks.

ABSTRACT:

High mountain landscapes in the Iberian Peninsula are a consequence of both Quaternary glaciations and post-glacial environmental dynamics driven (mainly) by periglacial, slope and alluvial processes and shallow or deep-seated landslides [1]. A long discussion about the existence/non existence of clear glaciation evidences at low altitudes in the NW of Iberia take a lot of research efforts and discussions about the two theories. This indefiniteness was linked with the presence of few and poor clear evidences of the glacial extent, in terms of undisputed erosive and/or depositional glacial forms.

Nevertheless, for the Northwest of the Iberian Peninsula, several studies confirmed the presence of glacial forms at low altitudes [2]. In this way, the work done by other researchers [3,4,5,6,7], among others, is retaken by this study concerned with the geomorphic inheritance of the Pleistocene Glaciation at the Alto Vez spot, a sector of the Soajo-Peneda Mountains, placed in the Peneda-Gerês National Park. Located in the Northwest of Continental Portugal, in an area that covers part of the municipalities of Arcos de Valdevez, Melgaço and Monção, the Alto Vez spot has an altitude varying between 400m and 1416m, and slopes that surpass 600m of unevenness. The slopes are oriented 15% east and west and 14% southeast, with 71,4% of shady area.

The fieldwork recognition and the geomorphological mapping already executed during 2013-14 allowed sketching a preliminary view of the glaciated area and the registering of more geomorphic elements that prove the extension of the Alto Vez glaciation [8]. This previous work allowed the identification and the morphometry analysis of 25 glacier cirques, as well as the geomorphological cartography associated with intensive fieldwork, allowed to establish comparisons with other glaciated areas, namely, regarding the orientation of the glacial cirques to the east, particularly, in the sector Branda de Gorbelas - Branda das Bosgalinhas.

Following this gaps, we present in this work the experimental results related with the Pleistocene glaciation in the Alto Vez sector, namely by the detailed analysis of the main cirque towards to east, the Ramisquedo Cirque (RC). Four main results are achieved: i) an high detailed orthoimage of sectors of the cirque; ii) a detailed map of the glacial inheritance forms; iii) a detailed geological map of the RC; iv) an update interpretation of the geomorphic inheritance of the low/medium size glacial forms existent on the RC.

In April of 2017 it was performed a recent survey and UAV flights (one morning for the flights, 5 in total, and two days for the posterior fieldwork), in order to have a global orthoimage of the Ramisquedo Cirque (RC). It was an opportunity to realize the specific characteristics of flights with an UAV (low altitude flight), allowing images offering many advantages, such as: excellent resolution, large overlap and reduced execution time [9]. The flights took place at 50/70m of the ground and around noon, in order to have the sun as upright as possible. Wind conditions were not perfect (frequent bursts over 20 km/h), which compromises the quality and overlap of some photos and obliged to do flights with short duration (<10min).

It was used a self-construction UAV, an equipment of carbon with 900mm of maximum distance between the motors axes (class 900) with four motors (quadcopter) and pixhawk flight controller of the 3DR. This flight controller features inboard barometer and accelerometers, and a peripheral GPS antenna and compass. With a total weight in flight of about 2,5kg carries on board a Canon Powershot SX260 (12 Mp) conventional camera equipped with GPS. In order to provide the timer camera, which is indispensable for the acquisition of photographs during flight, this camera has a CHDK script on its memory card. For the flight planning, it was used the open source Mission Planner software, making it possible to plan the flight independently using various base maps, selecting the Google Satellite View for this work.

At the field, it was used the differential GPS model Leica SR20, with a stationary and a mobile equipment allowing the positioning improvement by differential correction in post-processing. In addition, some control points (marked with red crosses on the terrain surface and in observable positions on aerial photos) were also collected. The photos obtained were processed with Agisoft software, resulting a global orthoimage with 5 cm of pixel size. Digital terrain and surface models were also processed as auxiliary base maps to identify and differentiate exposed inherited glacial forms from other types of erosional or deposition features/forms.

Fieldwork recognition and referencing of the glacial forms was assisted by the orthoimage and complemented with a portable Garmin GPSMAP® 64st. Figure 1 shows the integration between the fieldwork data and the UAV orthoimage on a little sector of the Ramisquedo cirque. The UAV orthoimage (Fig. 1e) is the result of the third flight, covering an area of ~35000m^2, performed 50m above ground, with a duration of 5 minutes, including 55 photos with a pixel resolution of 2m.

Regarding the area lithology, since we cover a small area, the variations of colour and tonality are not significant, but allows distinguishing with great clarity the lithological differentiation. As it was already published in the Geological Map of Arcos de Valdevez, scale 1/50000 [10], the field knowledge acquired from the area reveals that there is only one type of granite with slight textured differences, and several metamorphic rock spots mainly at the base and specific slopes of the cirque. Plotting the contacts identified during the fieldwork it was obtained a rigorous geological map that reveals some differences (mainly, more precision) with previous maps and allows new interpretation about the cirque forms and the real displacement of erratic blocks.

In relation with the geomorphic elements it was possible to identify sets of salient and polished quartz veins, flutes, polished granite surfaces in various cirque locations, an interior depression at the base of the circus (a former lake?), several erratic shale blocks placed along the flat granite surfaces. With all measured data it was possible to obtain the average direction of the grooves existing in various forms and thus define the relative movement of the ice mass on the surface of the circus.

Concluding, the quality of the orthoimage obtained by the aerial photos of the UAV to perform detailed cartography on this former glaciated are was excellent. One great advantage comes from the precise and detailed characterization of geological and geomorphological features exposed along the cirque area, allowing rigorous position, detailed morphometric measures and establishing relations about ice mass dynamics on the cirque surface.

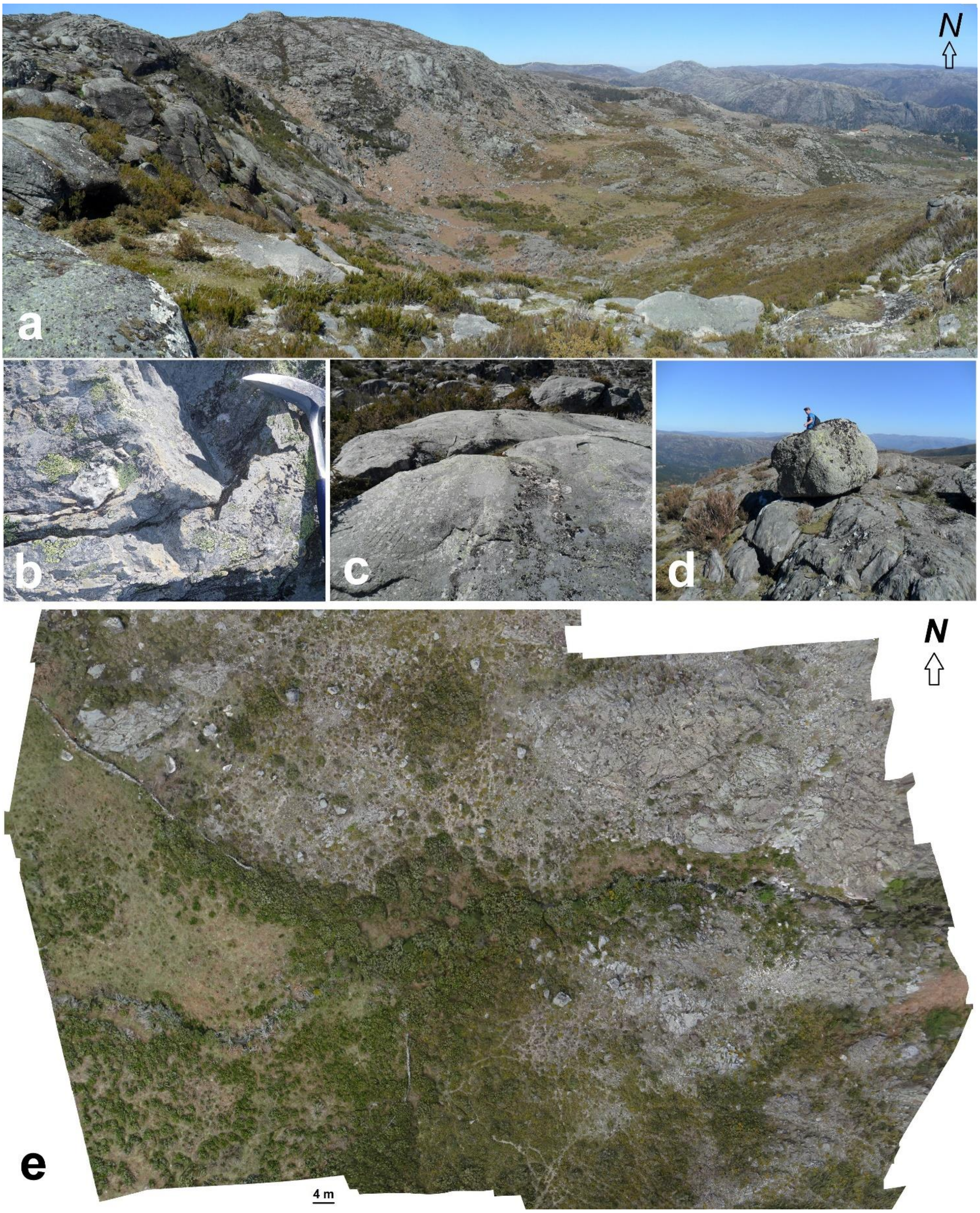


Figure 1. Drone orthoimage and field evidences of the quaternary glaciation at the Ramisquedo cirque: a) panoramic view of the Ramisquedo cirque; b) polished surfaces on the metamorphic basement and quartz veins; c) polished surfaces on granite outcrops; d) erratic granitic blocks over metamorphic basement; e) drone orthoimage of the central/bottom sector of the cirque, with many erratic blocks and polished/eroded surfaces, and clear quartz veins.

The use of UAVs in comparison with other data acquisition techniques is very advantageous since the costs and time spent in collecting and processing the data are relatively short. Processing images can even be carried out on-site, which allows an immediate result to be visualized and facilitates the correction of errors through repeated flights, which is very important for these places of difficult access. The great and sudden variety of wind conditions could be a difficulty to operate in this environment. Since the inherited glacial forms are dispersed over a large area (several kilometres), the use of UAV devices with low autonomy (covered area and flight duration) requires more efforts and flights to perform a good survey. Nevertheless, flights easiness repetition and speed of data processing makes it an accessible tool and very effective for detailed studies of the geomorphic evidences of low altitudes glaciation in the Iberian Mountains.

References:

1. Oliva, M., Serrano, E., Gómez-Ortiz, A., González-Amuchastegui, M.J., Nieuwendam, A., Palacios, D., Pérez-Alberti, A., Pellitero-Ondicol, R.J., Ruiz-Fernández, J., Valcárcel, M., Vieira, G. & Antoniades, D., (2016). Spatial and temporal variability of periglaciation of the Iberian Peninsula, *Quaternary Science Reviews*, 137, 176-199.

2. Perez-Alberti, A.P., Rodríguez Guitián, M. & Valcárcel Díaz, M. (1993). Las formas y depósitos glaciares en las sierras orientales y septentrionales de Galicia (NW Península Ibérica). *Xunta de Galicia*, 61-90.

3. Coudé-Gaussen, G. (1981). Les Serras da Peneda et Gerês. *Memórias do CEG*, 5, 254 p.

4. Coudé, A., Coudé-Gaussen, G. & Daveau, S. (1983). Nouvelles observations sur la glaciation des montagnes du Nord-Ouest du Portugal. *Cuadernos do Lab Xeolóxico de Laxe*, 5, 381-393.

5. Moreira, A. & Farinha Ramos, J. (1981). Vestígios de glaciações na serra da Peneda (Noroeste de Portugal). *Comunicações dos Serviços Geológicos de Portugal*, 67 (1), 95-98.

6. Pereira P., Pereira D.I. & Casinhas P. (2009). Novos dados sobre a glaciação no sector Gorbelas-Junqueira (Serra da Peneda). *Associação Portuguesa de Geomorfólogos*, 6, 101-106.

7. Santos, J., Cunha, L., Vieira, A. & Bento-Gonçalves, A. (2013). Genesis of the Alto Vez glacial Valley Pleistocene moraines, Peneda Mountains, Northwest Portugal. *Atas do VI Congresso Nacional de Geomorfologia*, 57-62.

8. Martins, C., Pereira, J., Pérez-Alberti, A. & Gomes, A. (2014). A glaciação Plistocénica do Alto Vez (PNPG): morfometria dos circos, espessura da língua glaciária e esboço geomorfológico preliminar. *Atas do XIV Colóquio Ibérico de Geografia*, 2182-2187.

9. Humphrey, D. (2014). UAV and GIS, an emerging dynamic duo. Available at <http://www.esri.com/~/media/Files/Pdfs/news/arcuser/0314/uav-and-gis.pdf>.

10. Moreira, A. (1985). Carta Geológica de Arcos de Valdevez - folha 1D (escala 1/50000). *Serviços Geológicos de Portugal*.

RPAS FOR PRECISSION GREENKEEPING AND IMPROVED WATER MANAGEMENT IN GOLF COURSES

López-Ramírez, J. A [(1)], Talavera Madrigal, L [(1)], Barbero Gonzalez, L. C. [(1)]

[(1)] *University of Cadiz, Spain, (juanantonio.lopez, lara.talavera, luis.barbero) @uca.es*

Key-Words: water management, golf courses, RPAS, precission greenkeeping.

ABSTRACT:

Turf irrigation is one of the most important activities that are carried out in golf courses. Its main goal is to provide the adequate amount of water to the turf in order to achieve a good plant development and to facilitate the game. If the field looks with a suitable aesthetics greenkeeper's objectives are fully accomplished. The quantity and quality of the required irrigation water will depend on numerous factors, sometimes outside the control of the technician: local climatology, meteorology, latitude, orography, field design, plant type, vegetative state, soil type and characteristics, source of water, availability of water source, variability of water quality, etc. So, optimal irrigation involves making a serie of decisions that may not always be right. In wet and rainy areas rainfalls may be almost sufficient to maintain a field adequately, however, in areas of warm climate, which allow playing in all seasons, and logically are the most demanded, it is necessary to draw on to frequent irrigation. For this, two important aspects need to be considered: quantity and quality of water. From the point of view of quantity, two extreme situations can occur with respect to irrigation and must be prevented: 1) there is little available water, with a consequent risk to the life of the plant, or 2) over-watering and appearing problems of watering, erosion, lack of root oxygenation, etc., also negative situations for the life of the plant. Both issues should be avoided at all costs and it is the responsibility of the greenkeeper to find the best option.

Different strategies can be issued for proper water management on golf courses: use of humidity soil sensors and meteorological towers, greenkeeper experience, etc. In southern Spain most of golf courses use reclaimed wastewater and must pay for it. This increases costs of golf courses management. So, a smart use of water is needed in order to fulfill golf courses needings and reducing water costs. Recent advances in the use of RPAS (remotely piloted aircraft systems) with multispectral and termopraphic sensors can help to monitor turf development and water management.

In this work, authors present preliminary results of the use of RPAS using multispectral sensors to improve water management in a golf course of South Andalucia, Spain. Fairways state is compared before irrigation and after it along a period to reduce water consumption. Vegetation indexes are used to analyze areas where maybe excess irrigation or lack of it is being carried out. In this way water consumption can be compared with historical data. These results can help to improve water management in similar warm areas and to enhance greenkeeping practices.

THE RIGHT UAS FOR YOUR AGROFORESTRY APPLICATION: A WEB-BASED DECISION SUPPORT SYSTEM

Ricardo Pereira[(1)] , Manuel Pimenta[(1)], Telmo Adão[(2)], Luís Pádua[(1)], Jonáš Hruška[(1)], Jakub Vanko [(1)], Joaquim J. Sousa[(2)], Emanuel Peres[(2)], Raul Morais[(2)]

[(1)] Department of Engineering, School of Sciences and Technology, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal, ricardogoncalvespereira94@gmail.com, manuelalexandrepimenta@gmail.com, luispadua@utad.pt, jonashrus@gmail.com, vanko.jakub@gmail.com

[(2)] Department of Engineering, School of Sciences and Technology, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal; INESC-TEC (formerly INESC Porto), Porto, Portugal, telmo.adao@gmail.com, jjsousa@utad.pt, eperes@utad.pt, rmorais@utad.pt

Key-Words: UAS; UAV; Sensors; Selection decision support; Agroforestry; Agriculture; Forestry; Application; Web system

ABSTRACT:

Unmanned Aerial Systems (UAS) combine Unmanned Aerial Vehicles (UAV) and different types of sensors and have been widely used in Agroforestry and related areas to perform tasks that range from forest inventory to animal detection and crop monitoring. Some examples for agriculture include water status verification [1], vigour assessment [2] and biomass estimation [3] while inspection of forestry operations [4] wildfire detection [5] and health monitoring [6] are typical tasks on the forestry field. Regarding the best UAV-sensor pair to use, it depends on three main factors: area of application, task and land cover range. For example, fire detection and monitoring in forests is more suitable of being achieved by fixed-wing UAVs (for covering large extension of terrain) and thermal sensor (due to the capability of discriminating heat zones). Disease detection, which is usually an agriculture related task, can be performed by using rotor-based or fixed wing UAVs (depending on the parcel specifications) either using hyperspectral or multispectral sensors. These aspects were already addressed in [7] to guide agriculture and forest professionals in the selection of the most suitable setup, according to specific area and task, as it is summed up by Fig. 1. Additionally, it is important to be aware that, in most cases, rotor-based UAVs are for short-range areas as fixed-wing UAVs are for wider areas.

Currently, finding the right UAS (UAV + sensor) for agroforestry applications requires consulting scientific or technical literature, coercing new users to deal with more information than they are looking for. In addition, the increasingly use of these aerial systems in different contexts and areas will, expectably, create transformations in this field - either (1) because of the technological development that is prone to bring new devices to light or (2) due to the application of UAS to new agroforestry purposes and respective tasks - leading to the need of keeping in touch with the last updates by the same literary sources which, in turn, can be quite cumbersome to manage. Also, contacting enterprises making business with this kind of equipment to ask for recommendations might result in delayed decisions influenced by a marketing tendency rather than be taken with impartiality.

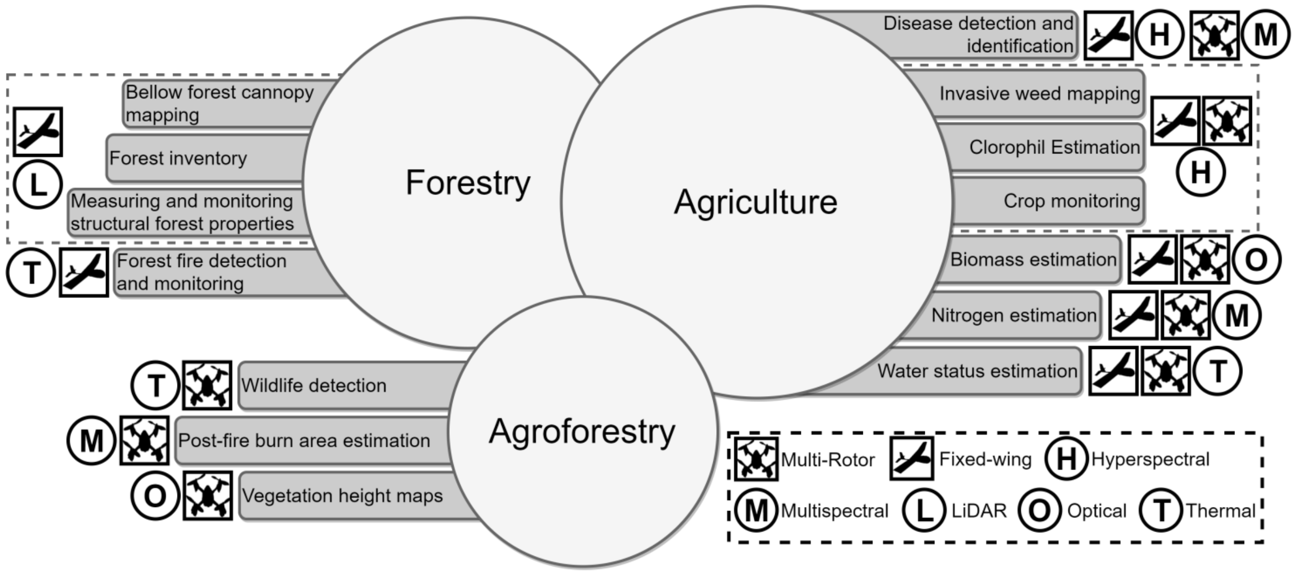


Figure 1. Guidelines for the selection of UAV + sensor, by application areas and respective tasks [7].

Thereby, an updatable web-based platform capable of helping professionals/researchers to rapidly select the best UAS for the intended area and task is proposed in this poster, relying in known guidelines [7]. More specifically, the user can search for UAVs or sensors, in particular, to know which areas/tasks are the most suitable for the application of the selected set. Alternatively, the selection of an area along with a specific task to meet the most appropriated UAS is also contemplated. Moreover, scientific papers fitting the parameters of each user search are also retrieved at runtime by a system agent that carries out a web search – taking advantage of the semantic capabilities of search engines such as Google Scholar [8] – with the goal of providing reliable validation sources for search results. Finally, a system manager is responsible for keeping the information related with UAVs, sensors, areas and tasks updated as well as settle the proper relations between configurations (UAV + sensor) and purposes (area + task). Fig. 2 depicts a use-case diagram complying with the previous specification.

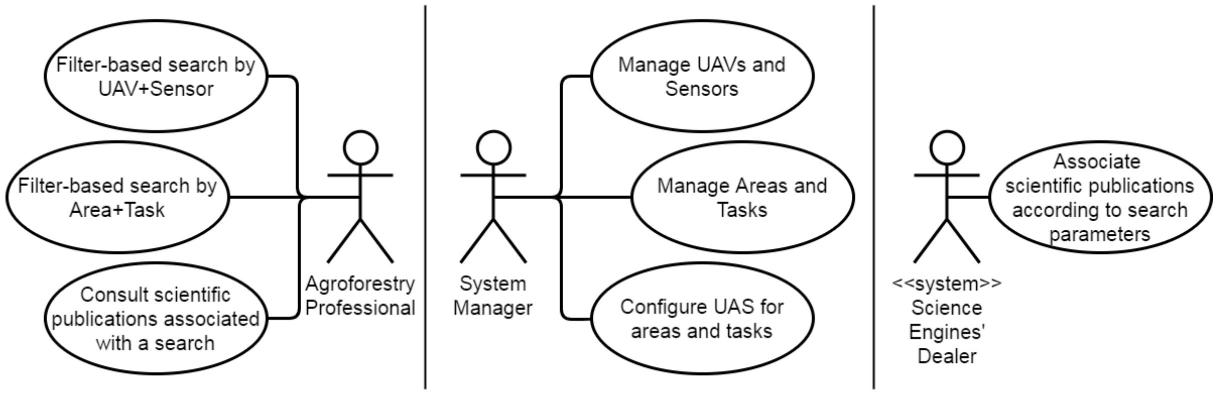


Figure 2 – Use-case depicting main functionalities for agroforestry professional, system manager and system's dealer agent to interface science engines.

A provisional entity-relation (E-R) model (see Fig. 3) was design to enable several combinations between main entities, i.e., UAV, Sensor, Area and Task. More specifically, UAV and Sensor instances can be paired up to serve a purpose mapped by the Task and Area tuple. Additional entities were integrated to complement E-R model while ensuring scalability, namely: (1) Category which allows to classify UAVs (for example, in "Rotor-based" and "Fixed-wing") and sensors (for example, in Red-Green-Blue, Near Infrared, Multispectral and Hyperspectral); and (2) Extension which refers to the land cover range capabilities.

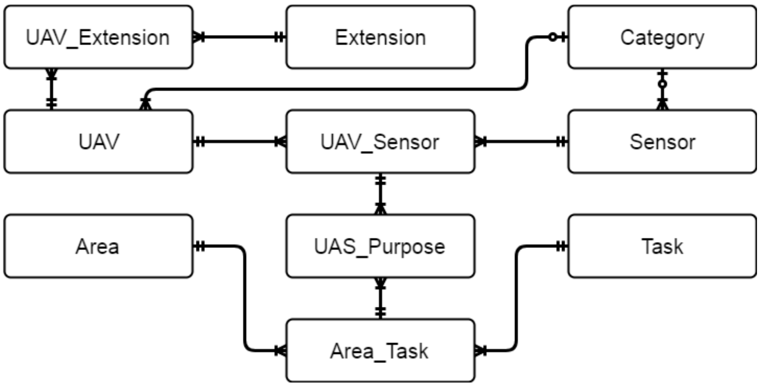


Figure 3 – Entity-relation model depicting data storage structure of the proposed web-based system.

Poster regarding this web system shall provide more specification details in the form of schematic representations to improve public's insight. Additionally, main implementation aspects - including development technologies and layout organization - will be presented along with a brief user guide. This system complements and consolidates the work done in [7] and intends to constitute an innovative web portal for those who desire to rapidly obtain valuable guidelines indicating the best UAS candidates to be used in the most diverse agroforestry tasks and respective areas.

Acknowledgements:

This work was financed by the European Regional Development Fund (ERDF) through the Operational Programme for Competitiveness and Internationalisation - COMPETE 2020 under the PORTUGAL 2020 Partnership Agreement, and through the Portuguese National Innovation Agency (ANI) as a part of project "PARRA - Plataforma integrAda de monitoRização e avaliação da doença da flavescência douRada na vinhA" (Nº 3447) and ERDF and North 2020 – North Regional Operational Program, as part of project "INNOVINE&WINE – Vineyard and Wine Innovation Platform" (NORTE-01-0145-FEDER-000038).

References:

1. S. Park et al., 'Estimation of crop water stress in a nectarine orchard using high-resolution imagery from unmanned aerial vehicle (UAV)', presented at the 21st International Congress on Modelling and Simulation, Gold Coast, Australia, 2015, pp. 1413–1419.
2. J. Primicerio et al., 'A flexible unmanned aerial vehicle for precision agriculture', Precis. Agric., vol. 13, no. 4, pp. 517–523, Aug. 2012.
3. J. Bendig et al., 'Combining UAV-based plant height from crop surface models, visible, and near infrared vegetation indices for biomass monitoring in barley', Int. J. Appl. Earth Obs. Geoinformation, vol. 39, pp. 79–87, Jul. 2015.
4. S. Getzin, K. Wiegand, and I. Schöning, 'Assessing biodiversity in forests using very high-resolution images and unmanned aerial vehicles', Methods Ecol. Evol., vol. 3, no. 2, pp. 397–404, Apr. 2012.
5. L. Merino, F. Caballero, J. R. Martínez-de-Dios, I. Maza, and A. Ollero, 'An Unmanned Aircraft System for Automatic Forest Fire Monitoring and Measurement', J. Intell. Robot. Syst., vol. 65, no. 1–4, pp. 533–548, Jan. 2012.

6. M. Smigaj, R. Gaulton, S. L. Barr, and J. C. Suárez, 'Uav-Borne Thermal Imaging for Forest Health Monitoring: Detection of Disease-Induced Canopy Temperature Increase', ISPRS - Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci., vol. XL-3/W3, pp. 349–354, Aug. 2015.
7. L. Pádua et al., 'UAS, sensors, and data processing in agroforestry: a review towards practical applications', Int. J. Remote Sens., vol. 38, no. 8–10, pp. 2349–2391, May 2017.
8. 'Google Académico'. [Online]. Available: https://scholar.google.pt/. [Accessed: 20-May-2017].

A UAV AND SFM APPROACH AS A FAST AND COMPLETE METHODOLOGY ON MORPHOSTRUCTURAL ANALYSIS

João Duarte [1] , Marco Cunha [2], Gil Gonçalves [3] , Fernando Figueiredo [4]

[1] IQGeo – Serviços, Lda. and Centro de Geociências, University of Coimbra (Portugal), joao.aduarte@iqgeo.pt

[2] GeoSurveys – Consultores em Geofísica, Lda (Angola), marcoaureliocunha@gmail.com

[3] Dep. of Mathematics, University of Coimbra and INESC-Coimbra (Portugal), gil@mat.uc.pt

[4] Centro de Engenharia Mecânica da UC e Centro de Geociências da UC, Portugal, fpedro@dct.uc.pt

Key-Words: UAV Photogrammetry, SFM, Morpho structural analysis, Open-source software, Digital outcrop

ABSTRACT:

Combining UAV near nadiral images with Structure from Motion (SFM) technology has been proven as a fast and cheap approach for surveying and mapping large areas, producing high resolution orthophotomaps and high resolution Digital Surface Models (DSM). Using a similar LIDAR workflow for UAV's dense point cloud classification, the separation between Ground Points and Non-Ground Points can be achieved. Moreover, interpolating a Digital Terrain Model from these ground points we can used it for the most various surface studies, such as morphostructural analysis. With the 3D digitalization of an outcrop, and it's DTM generation, it is possible to use the surface data to measure and quantify several morphostructural aspects, such as dips and directions of stratification, faults, fractures, and others that to date were commonly measured only with the conventional way (ruler, compass, clinometer). Not to be meant as a substitute, the techniques described aim to enrich to knowledge of any outcrop, by performing morphostructural analysis in areas with difficult or danger access to the geologist/surveyor.

The methodology used for the morphostructural analysis is based on the automatic or semi-automatic determination of discontinuity in outcrops (Figure 1). Through the point cloud generated by photogrammetric processing, it is possible to determine the strike and dip of planar structures, linear structures, the spacing between elements. These elements are extremely important for the morphostructural analysis of the area under consideration, and many more. Subsequently, the interpreted features can be projected in the orthophotomaps (Figure 2).

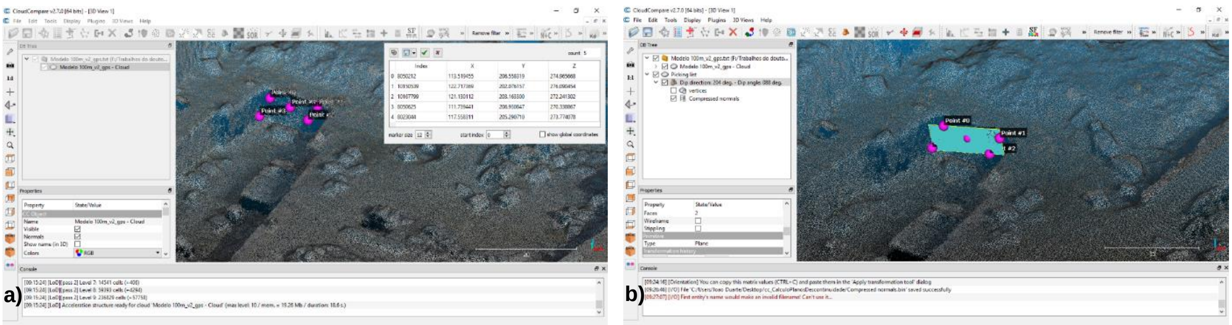


Figure 1-a) Picking points (minimum 3) on the surface of discontinuity identified in point cloud. b) Determination of the plane and attitude (automatic task).

Figure 2 – Projection the linear structures corresponding to the planes at orthophotomaps.

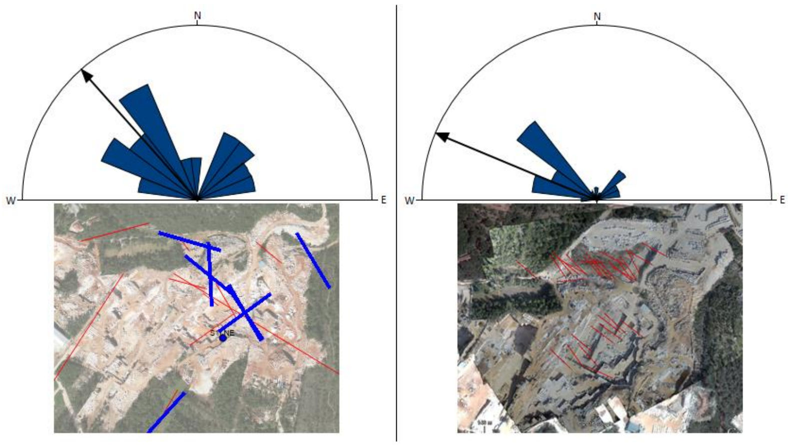


Figure 3 – Rose diagrams of linear structures identified with conventional survey (left) and

RESULTS:

In this paper, it is presented a structural analysis that uses both conventional (clinometer, and compass) and UAV photogrammetric techniques (using nadiral imagery). For the conventional technique, the following morpho structural figures were obtained: max value = 17.14% between 141° and 150°; mean vec = 318,8° ± 22,9°; Average Length = 0,296; Circular Variance = 0,7044; kappa = 0,6062 [Krumbein's axial mean; uncertainty is 1 standard error, for 95% confidence level multiply by 1.96]. For the UAV photogrammetric technique, we obtained: max value = 35.48% between 311° and 320°; mean vec = 315,1° ± 05,2°; average length = 0,887; Circular Variance = 0,11; kappa = 4,49 [vector mean; uncertainty is 1 standard error, for 95% confidence level multiply by 1.96].

The results were satisfactory in terms of accuracy versus time of acquisition/processing. The observed differences might be resultant of difference on linear structure's sampling. Same families of linear structures were preserved in both techniques with changes mainly on the quantification (Figure 3); the photogrammetric survey had higher sampling count. Lineaments, planes, as well as other surface features, can be easily identified and measured with UAV photogrammetry. The resultant digital outcrop can be also target of different approaches and studies, that aren't only morpho structural analysis, and/or integrated with subsurface/geophysical data.

THE TALES OF AKERATEHEILS – CAN RPAS BASED MAPPING OF ANCIENT GRAVES IMPROVE OUR UNDERSTANDING OF THE BLEMMY CULTURE?

Gidske L. Andersen(1) , Knut Krzywinski(2)

(1) Department of Geography, University of Bergen, P.O. Box 7802, N-5020 Bergen, Norway, Gidske.Andersen@uib.no
(2) Department of Biology, University of Bergen, P.O. Box 7803, N-5020 Bergen, Norway, Knut.Krzywinski@uib.no

Key-Words: Structure from motion, point cloud classification, point pattern, DJI P3P, Red Sea Hills, arid landscapes, ancient monuments

ABSTRACT:

While the Nile Valley cultures; Pharonic, Ptolemaic, Roman, Byzantine as well as the Nubian and Meroitic, are well documented in written and archaeological sources, little is known of the cultural history of the nearest neighbors of the great empires. The Beja tribes still have their home land in the desert between the Nile and the Red Sea. They were named *Medjay* in contemporary Pharonic-, *Blemmyes* in Greco-Roman- and *Beja* in Axumitic and Arab sources. In the Greco-Roman times until the Middle Ages the Blemmyes controlled the large desert areas between the Nile and the Red Sea and the routes across the desert between these empires and the Far East. They have not themselves left any written sources and we therefore have relied on how outsiders saw them.

The Blemmyes were described as pastoral nomads that constantly roamed with their animals. In contrast to sedentary cultures nomadic livelihood does not produce material culture that can be easily studied by archaeological methods. They lived in tents made of perishable material and among the things they carry mainly their few pottery items have a chance to survive until our time. Few archaeological studies have been dedicated to present Beja land, but since the 1980ies bits and pieces are slowly drawn together. However, our understanding of the Blemmy culture is still largely fragmented.

In contrast to nomads elsewhere and their ancestors the Medjay, the Blemmy made monumental graves. Among the present Beja they are called akerateheils and have until recently been respected as spiritual places. The city of Nubt is recognized as their capital in ancient sources and has up till now never been studied or mapped in detail. One of the most remarkable characteristic of this site is the huge number of indigenous graves. The akerateheils graves are circular structures built in stone with a central chamber where the diseased is buried. The structure can vary in size, both in width and height, but typically ranges between 1,5m to 20m in diameter and 0,5 to 1m in height. The graves are found on stone pediments along the dry river vallyes (khors) but also in high density and numbers on the surrounding hills and mountain ridges and slopes. A preliminary survey suggests that there are more 1000 graves in the vicinity of Nubt. Due to a current gold rush in the area and the content of gold in some graves, these ancient moments are now in the danger of plundering and destruction.

The aim of the current paper is to explore how RPAS based mapping and derived products can increase our ability to conserve and understand the sparsely known Blemmy culture. We used a DJI P3P RPAS and the Drone Deploy piloting software to collect data for the graveyard area. The collected imagery was processed using structure from motion algorithms to generate 2D and 3D products. The dense point cloud was classified to extract terrain and surface models. These were used to identify and generate 3D objects representing akerateheils in the area. The derived structural information of grave objects is together with their spatial location further explored to uncover any geographical patterns that can contribute to our understanding of the

Blemmy culture. The paper will also address some of the practical and logistic challenges of RPAS-based studies in remote areas.

UAVs FOR SUSTAINABLE FORESTRY

Patrick Ribeiro[1]

[1] OpenForests, Germany, patrick.ribeiro@openforests.com

Key-Words: forestry, sustainable forestry, drones, UAV, transparency, monitoring, remote sensing

ABSTRACT:

With the globally growing demand for timber the pressure on natural forest resources increases continuously. Large scale production-efficient timber plantations are seen as a necessity to satisfy demand. At the same time, these industrial forest plantations have shown a devastating negative impact on ecosystems and local communities.

Facing the current problems of large scale plantations, forestry operations need to become in general more ecological and socially adapted to stay productive for an unlimited period of time. Although the number of sustainable forestry operations is increasing worldwide, considerable investments are needed to unleash the full potential of such projects. The limited capital flow into the sustainable forestry sector is caused - among others - by the present information situation which is diffuse, scarce and non-transparent.

OpenForests is engaged in developing and providing tools which allow a solid and transparent information basis for decision makers like forest managers and investors. In this context, UAVs play a major role. From visual project presentations to extensive data acquisition and analysis, UAVs allow a new level of transparency facilitating investment decisions, enabling a data driven forest management and controlling, and helping to increase the project presence and visibility on the market.

I will present some of the UAV based applications OpenForests presently employs in the forestry context and elucidate with practical examples how they assist in sustainable forestry.

COMPARISON OF POINT CLOUDS OBTAINED FROM TERRESTRIAL LIDAR (TLS) AND UAV VERTICAL SURVEYING IN FORTE NOVO BEACH AND CLIFF (QUARTEIRA, PORTUGAL)

João Manuel Calvão Rodrigues(1)

(1) Universidade de Lisboa, DEGGE, IDL, jmrodriguesc.ul.ptl

Key-Words: Terrestrial Laser Scanning (TLS), UAV, point clouds, M3C2

ABSTRACT:

Continental Portugal has got a wide coastal area whose exposure to erosion is important. Bearing in mind the risk analysis and its minimization, to get to know in detail this coastal strip and the geodynamical processes which are developed there is essential to the sustainable management of the sea-land interface.

On the area under study, the cliff is approximately 360 m long and 10 m high, being protected from the direct sea action due to the beach in its basis. In this paper we have compared the results of two contemporary surveys carried out in 2016 by means of terrestrial laser scanner (TLS) and UAV on the cliff and the beach, aiming to identify the advantages and disadvantages of each methods in 3D modelling for geomorphologic studies. For this study a method based on profiles is compared with M3C2 method applied on the dense point clouds that were produced in each survey.

COMBINING UAS AND HISTORICAL AERIAL IMAGERY SFM PHOTOGRAMMETRY FOR CULTURAL HERITAGE DOCUMENTATION AND RESEARCH: THE CASE OF TORRE DE MODORRA (VINHAIS, NORTHERN PORTUGAL)

João Fonte(1), José Manuel Costa-García(2), Óscar Moutinho(3), Ana Rodrigues(3), Lia Duarte(4), José Alberto Gonçalves(5)

(1) Institute of Heritage Sciences (Incipit), Spanish National Research Council (CSIC), Santiago de Compostela, Spain / Department of Archaeology, University of Exeter, Exeter, UK; joao.fonte@incipit.csic.es
(2) Universidade de Santiago de Compostela, Santiago de Compostela, Spain / Vrije Universiteit Amsterdam, Amsterdam, The Netherlands; josemanuel.costa@usc.es
(3) Eye2Map Lda., Porto, Portugal; info@eye2map.com
(4) Department of Geosciences, Environment and Land Planning, Faculty of Sciences, University of Porto, Porto, Portugal; liaduarte@fc.up.pt
(5) Department of Geosciences, Environment and Land Planning, Faculty of Sciences, University of Porto, Porto, Portugal; jagoncal@fc.up.pt

Key-Words: UAS, historical aerial imagery, lose range, SfM photogrammetry; Cultural heritage.

ABSTRACT:

Structure from Motion (SfM) photogrammetry has been frequently used to document and research cultural heritage. This is due to its straightforward and nearly automatic use, which conjugates an easy workflow with accurate results. When dealing with architecture, Unmanned Aerial Systems (UAS) photogrammetry is capable of providing the aerial perspective of the top of a building, but also to obtain an accurate information of its façades, in order to fully capture 3D data from an historical building. Additionally, we incorporate a diachronic perspective through the use of historical aerial imagery, which was also photogrammetrically processed.

To process these images, a GIS open source application, MicMacGIS, was used [1] and improved with new pre-processing functionalities: (i) the automatic creation of shapefiles with the projection centre of the camera: this process allows to check if one photograph is missing in any of the strips and to analyse the position of each photo (ii) the creation of shapefiles with the area covered by each photograph, in order to understand the overlap between the photos allowing to check if the area of interest is correctly covered; and (iii) accounting the number of images that overlap in each location assigning the number to raster surfaces, which is helpful to analyse if the overlapping is enough for a multiview stereo. In order to obtain these outputs, the user must define the flight height value. The coordinates of the camera projection centre are automatically extracted and some equations based on focal distance, heading, and trigonometry formulas were implemented to generate the area covered by the photo. After that, the photo corners coordinates are obtained and a polygon is automatically created with the photo area. In the final step, the polygon shapefiles are converted to raster with v.to.rast.value algorithm from GRASS. With all the raster created the number of overlapped photos are obtained with r.series algorithm from GRASS, which allows to make each output pixel value the sum of the values assigned to the corresponding pixel in the input raster maps.

Our case study was the Torre de Modorra (Vinhais, Northern Portugal), a possible Roman military tower. This stone building suffered great damage in the last decades, being now at risk of collapse. The UAV used for this survey was the 3DR Solo, a small multirotor with a Canon SX230HS camera, triggering at every 2 seconds. The open source software Mission Planner was used to design the flight plan. This was calculated to cover two adjacent fields in order to measure the tower and search for possible remains nearby. The images have

70% overlap and sidelap at 40 meters of above ground altitude, corresponding to a ground sampling distance of 1.2cm. Ground control points were deployed using pink circular markers with 22cm diameter. The marker's coordinates were measured using a GNSS RTK receiver, a Trimble R6 with centimetre accuracy to be used within photogrammetric processing in absolute orientation. Orthomosaic and Digital Elevation Model were generated as result of this survey. This methodology allowed us to carry out a rigorous survey of this historic building, but also to get some insights in relation to its original structure and its historical context, through the combination with other available information sources, taking into account that a good survey engages with the history of the building [2].

References:

1. Bertocci, S. & Bini, M. (2012). Manuale di rilievo architettonico e urbano. Novara, CittàStudi.
2. Duarte, L., Teodoro, A.C., Moutinho O. & Gonçalves, J.A. (2016). Open-source GIS application for UAV photogrammetry based on MicMac. *International Journal of Remote Sensing*, 38(8-10), 3181-3202. DOI: 10.1080/01431161.2016.1259685

UAS PHOTOGRAMMETRY FOR THE GEOARCHAEOLOGICAL SURVEY OF ANCIENT MINING LANDSCAPES

João Fonte[(1)], Alexandre Lima[(2)], José Alberto Gonçalves[(2)] and Luís Gonçalves Seco[(3)]

[(1)] Institute of Heritage Sciences (Incipit), Spanish National Research Council (CSIC), Santiago de Compostela, Spain / Department of Archaeology, University of Exeter, Exeter, UK; joao.fonte@incipit.csic.es

[(2)] Department of Geosciences, Environment and Land Planning, Faculty of Sciences, University of Porto, Porto, Portugal; (allima, jagoncalv)@fc.up.pt

[(3)] CITEI, Instituto Universitário da Maia, Maia, Portugal / Research Centre on Geo-Spatial Science (CICGE), University of Porto, Porto, Portugal; lgseco@ismai.pt

Key-Words: UAS, SfM photogrammetry, ancient mining areas.

ABSTRACT:

Structure from Motion (SfM) photogrammetry has been widely used within geoarchaeological studies. This is due to its straightforward and nearly automatic use, which conjugates an easy workflow with accurate results. Unmanned Aerial Systems (UAS) allow a “bird's-eye view”, enabling the acquisition of low-altitude aerial photos and thus the survey of geological and archaeological sites and landscapes. In this study, we have used UAS photogrammetry for survey ancient mining areas which are characterized by complex forms and structures, providing fast and reliable data collection and precise results, improving their mapping and characterisation. Additionally, we incorporate a diachronic perspective with the use of historical aerial imagery, which was also photogrammetrically processed.

We will focus on two case studies: the open-pit Roman gold mining areas of Janarde (Arouca, Portugal) and Outeiro Machado (Chaves, Portugal), presenting and discussing the potential of UAS photogrammetry as a cost-effective method to survey and map ancient gold mining infrastructures.

The observation of these images and models help on geological interpretation of the open-pit mining areas, contributing to the detailed knowledge not only of the ancient mining works, but also on update geological models that explain the ancient exploited mineral deposits.

We have used a battery-powered quadcopter (DJI Phantom 3 Pro), inbuilt with a 12-megapixel camera sensor and GNSS photo tagging, allowing easy remote control and flight planning and maximum flight time around 20 minutes. Images were processed using a SfM photogrammetry software in order to generate accurate orthomosaics, digital surface models (DSMs) and 3D models. We have collected ground control points (GCPs) to enable a correct rectification and georeferencing and to verify the accuracy of the models. Due to the terrain irregularity, we have tested several flight plans, with different flight altitudes, levels of side and front image overlap in order to compare different ground sampling distance (GSD) resolutions, and we have implemented point cloud classification and filtering to remove vegetated areas.

CHANGE DETECTION AND SPATIAL DYNAMICS OF LAND COVER DEGRADATION IN THE SOUTH EAST AURÈS (ALGERIA)

Hassen Benmessaoud [(1)] , Abdelhafid Bouzekri [(2)]

[(1)] Department of Ecology and environment, Faculty of Nature and life sciences, University of Batna 02, Fesdis, Batna, , Postal Code 05077, Algeria
[(2)] Department of Territory Development, Faculty of Earth Sciences, Geography and Land Use Planning. University of Constantine. Location: Campus Zouaghi Slimane Route de Ain el Bey 25000 Constantine –Algeria

Key-Words: Change detection, Land Cover, Degradation, Southeast of Aurès.

ABSTRACT:

The present work presents the results of a study concerning land use mapping and its spatial change detection using remote sensed images of Landsat (MSS 1972, TM 1987, TM 2002 and OLI 2015).

The objective of this study is to determine the contribution of the satellite images in the detection of ground occupation changes and to pursuit in forms of forest degradation between the four dates in the area East Aurés in Algerian.

Our methodology is based on data analysis of fieldwork observation in the Southeast of Aurès, thematic maps information allowed to identify four principle types of land use (Forests, Steppes, Cereal culture and Sandy soil)

The obtained results show a high degradation of forest cover and the disappearance of sand formations in the study area.

This study is a multi-temporal diagnosis, which has allowed us to identify at a time the degradation affecting vast semi-arid areas, causing regression of plant cover, and the pace of its development.

THE TREE OBSERVATORY AS A TEST BED FOR UAS APPLICATIONS TO STUDY TREES

Lane Scher[(1)] , Charles Cannon[(2)]

[(1)] *The Morton Arboretum, 4100 IL Route 53, Lisle, IL, 60532, USA, lscher@mortonarb.org*
[(2)] *The Morton Arboretum, 4100 IL Route 53, Lisle, IL, 60532, USA, ccannon@mortonarb.org*

Key-Words: Tree physiology; multispectral sensors; photogrammetry.

ABSTRACT:

The Center for Tree Science, a new initiative at the Morton Arboretum, is proposing to establish a "Tree Observatory" consisting of intensive and continuous observation of whole trees as study subjects in an effort to develop a holistic understanding of the entire organism. We want to create an open-source platform to integrate and share observations and data from a variety of sensors and sampling devices. We think that UAS-based sensors and sampling devices will be particularly powerful since access to the tree canopy is difficult and costly. As a first step, we are using photogrammetry to create 3D digital models of each tree as a framework for understanding architecture, to monitor future growth and health, and as a platform for more detailed physiological and behavioral studies. Since October 2016, we have revisited six trees each month using automated flight paths to capture photos and produce 3D digital models in order to understand phenology across the entire tree crown. We are beginning to analyze tree architecture and structure to gain a better understanding of their whole physiology and biomechanics. In the future, we plan to incorporate other UAS-based remote sensing techniques, such as LiDAR, multispectral, and thermal sensors. We plan to produce 3D models of each tree colored by NDVI rather than visible light to monitor variation in photosynthetic activity across the crown. We also envision aerial sampling devices to further enhance our ability to access, collect, observe, and record phenotypic variation. Over the growing season in 2017, we will place continuously operating sap flow sensors according to the results of our architectural analysis to examine correlations between physiological and phenotypic variation. Identifying correlations between UAS-based observations and physiological data will improve our understanding of remotely collected data on a fine scale and help refine applications for UAS-based sensors. We hope to gain insight into early warning signs of tree decline or indications of how and why individual trees thrive that can be measured remotely and applied on a larger scale. We view the Tree Observatory as a proving ground for testing the feasibility and benefit of various sensors and an exploratory space for inventing and refining new types of UAS-based observations. Eventually, we hope to incorporate many additional kinds of data, including genetics, experimental crosses, nutritional balance and allocation through the tree. We also hope to invite other scientists to propose experiments and observations. We invite suggestions, comments, and collaborators to help us in this endeavor.

PHOTOGRAMMETRIC ANALYSES FOR HIGH RESOLUTION BATHYMETRYOF THE GEPATSCH RESERVOIR (TYROL, AUSTRIA)

Boschi Maximilian(1), Boschi Peter(1), Schletterer Martin(2)

(1) droneproject.at, Schneeburggasse 225, 6020 Innsbruck, Austria, max@droneproject.at
(2) TIWAG-Tiroler Wasserkraft AG, Eduard-Wallnöfer-Platz 2, 6020 Innsbruck, Austria, martin.schletterer@tiwag.at

Key-Words: reservoir bathymetry; Unmanned Aerial Vehicle (UAV); Structure from Motion (SfM).

ABSTRACT:

The Structure from Motion (SfM) method [1, 2] became a powerful tool for photogrammetric analyzes of satellite and aerial imagery. Thus the generation of orthomosaics and digital elevation models (DEM) using SfM is becoming increasingly common.

The hydropower plant Kaunertal was built in 1961–1965 as high-pressure storage power plant with the annual reservoir Gepatsch, located in the Kaunertal valley. The dimensions of the reservoir are determined by a 600 m long dam crest, creating a length of about 6 km and a width up to 730 m, with a storage volume of about 138 Mio. m³.

In winter 2015/2016 a controlled drawdown of the Gepatsch reservoir took place [3], which was a unique chance to gain high resolution images and a topographical survey of the reservoir. To survey the bathymetry (between 14th and 23rd december 2015) of the Gepatsch reservoir an UAV (octocopter, Multirotor, service drone) was used. Beside the dataset of geotagged images, we measured 380 ground control points with a Leica Viva GS15 GNSS Rover to achieve a highly accurate, georeferenced model of the reservoir.

For optimal visual assessment a ground resolution of about 3 cm/pixel was selected. The camera-lens configuration (Lumix GH4, 14 mm fixed focal length) triggered a flight altitude of about 100 meters. Related to the confined flight time (capacity of the accumulator), the reservoir was divided into 20 sectors (Fig. 1). The blocks were surveyed with several autonomous flights (flight time 8 – 15 min each), which were performed if at least 6 GPS satellites were available. Flight planning was carried out with the software „Groundstation“. Due to lighting conditions in december, it was possible to fly between approx. 09:30 and 14:00, due to shading of the GPS signal.

The image processing (including georeferencing as well as removal of corrupt images) took place. The RAW-images that were selected for processing were optimized in Adobe Photoshop Lightroom. Subsequently the photogrammetric analysis was performed using the open source software MicMac/Apero [4].

We derived:

• orthophotos in 3 cm + 10 cm/pixel resolution

• point cloud

• digital elevation model (25cm) and contour lines

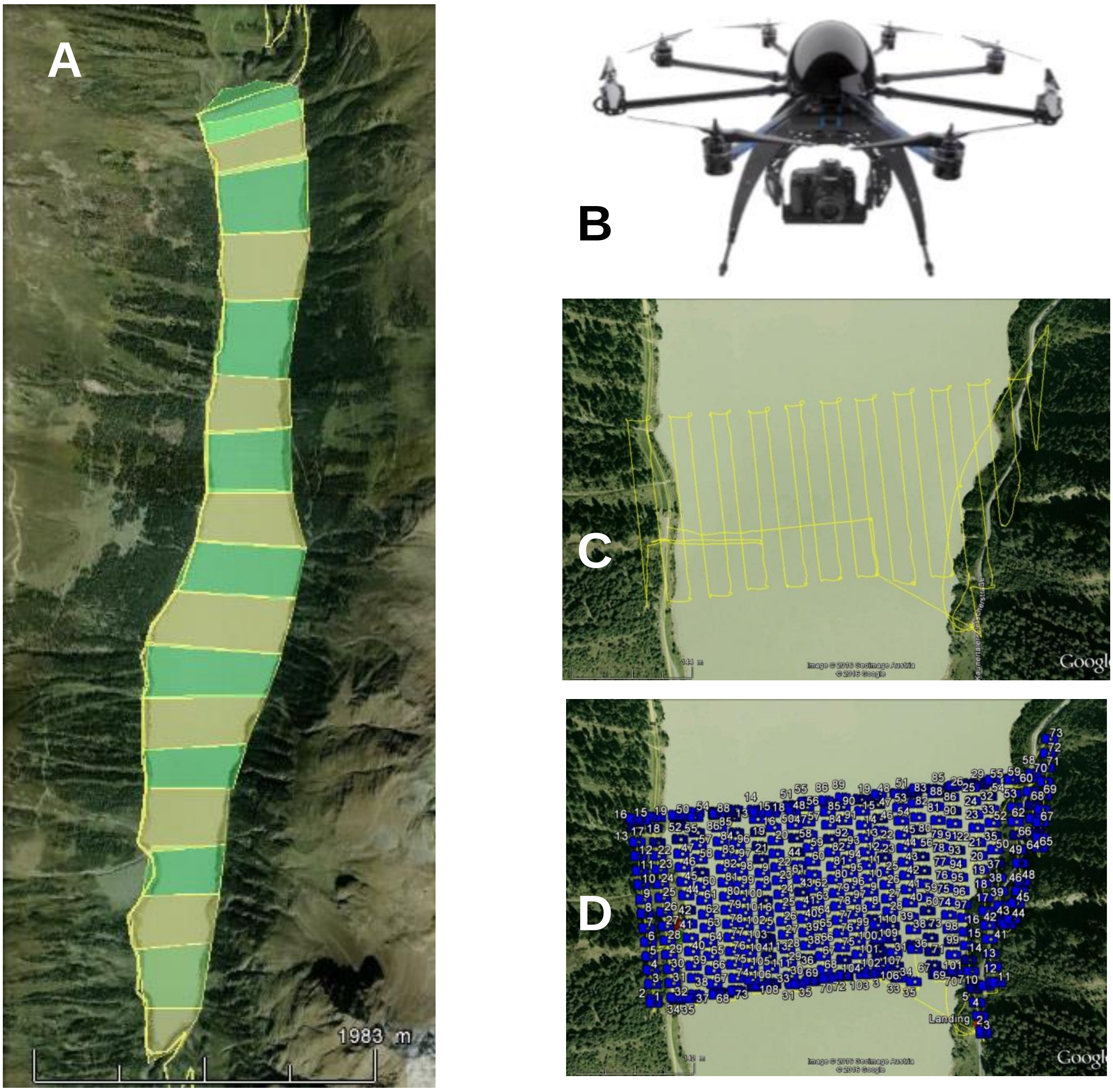


Figure 1. Gepatsch reservoir, A – overview on the 20 flight sectors (uppermost = 20), B – UAV MULTIROTOR service-drone, C – example for flight planning in sector 8 and D – corresponding camera positions

This case study underlines, that unmanned aerial vehicles (UAVs) can support remote sensing observations and enable the creation of a high resolution map. The procedure was supported by favourable weather conditions (late snow fall), i.e. despite winter period the assessment was possible without snow cover when the lowermost reservoir level was reached. We achieved an orthomosaic as well as a Digital Elevation Model (DEM) comprising high resolution bathymetric data of the Gepatsch reservoir (Fig. 2).

Possible applications range from archaeology, geography, mining, as well as civil engineering to ecology. In aquatic sciences, photogrammetric models became an important tool for detailed assessments of river segments [5], i.e. the generation of surface models as a basis for 2D hydraulic modelling and subsequent habitat modelling. But beside the step “from an image to coordinates”, additional application of spectral imagery from UAVs can support e.g. the Normalized Differenced Vegetation Index (NDVI) or the assessment of bark-beetles in forestry can be analysed using near infrared (NIR) imagery gathered by a multi camera system. Thus UAV generated datasets can provide an essential contribution to environmental intelligence gathering.

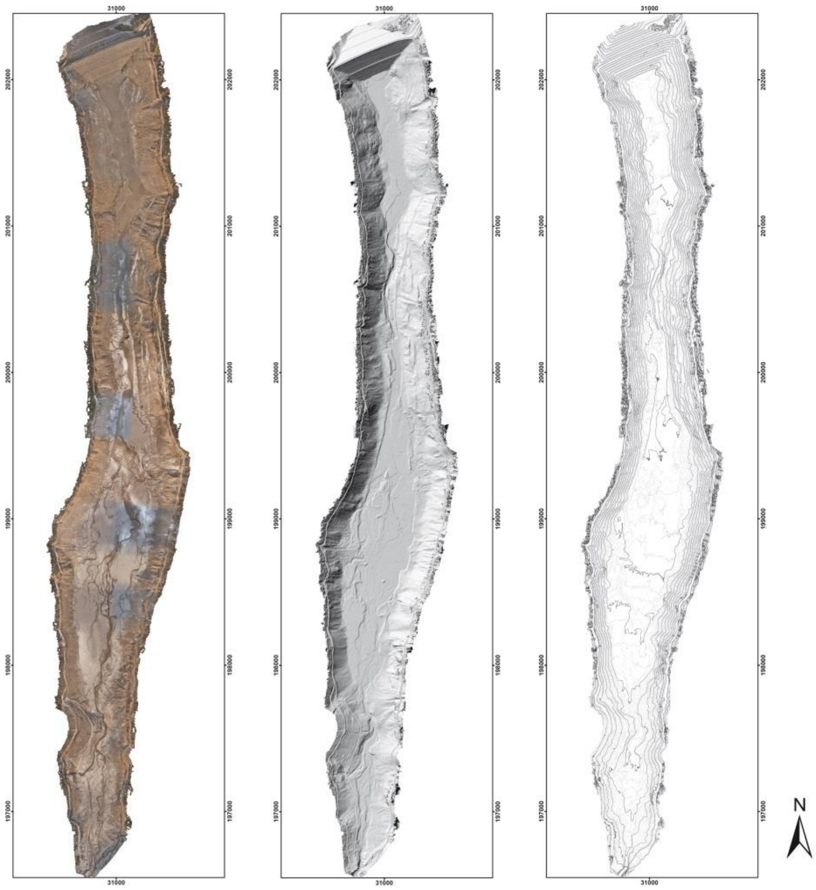


Figure 2. Orthophoto and DEM of the Gepatsch reservoir (December 2015)

References:

1. Snavely, N., Seitz, S.M., Szeliski, R. (2006). Photo tourism: exploring photo collections in 3D, in: *ACM Transactions on Graphics (TOG)*. ACM, pp. 835–846.
2. Snavely, N., Seitz, S.M., Szeliski, R. (2007). Modeling the World from Internet Photo Collections. *Int J Comput Vis* 80: 189–210. doi:10.1007/s11263-007-0107-3
3. Schletterer M., Hofer B., Obendorfer R., Hammer A., Hubmann M., Schwarzenberger R., Boschi M., Haun S., Haimann M., Holzapfel P., Habersack H., Brock B., Schmalzer B., Hauer C. (2017): Integrative monitoring approaches for the sediment management in Alpine reservoirs: case study Gepatsch (HPP Kaunertal, Tyrol). In: *Proceedings of 13th ISRS, Stuttgart; River Sedimentation* (ISBN 978-1-138-02945-3), Taylor & Francis Group, London, pp. 1161-1169.
4. Deseilligny A.P. & Clery I. (2011): Apero, an open source bundle adjustment software for automatic calibration and orientation of set of images. *International Archives of the photogrammetry, Remote Sensing and Spatial Information Sciences*, Volume XXXVIII-5/W16, ISPRS Trento Workshop 2-4 March 2011
5. Thumser et al. 2017 Thumser P., Kuzovlev V.V., Zhenikov K.Y., Zhenikov Y.N., Boschi M., Boschi P., Schletterer (2017, in press): Using structure from motion (SfM) technique for the characterisation of riverine systems – case study in the headwaters of the Volga River. *GEOGRAPHY, ENVIRONMENT, SUSTAINABILITY*

DEEPEYE: A UAS-BASED DEEP LEARNING FRAMEWORK FOR DETECTING DAMAGED BUILDINGS

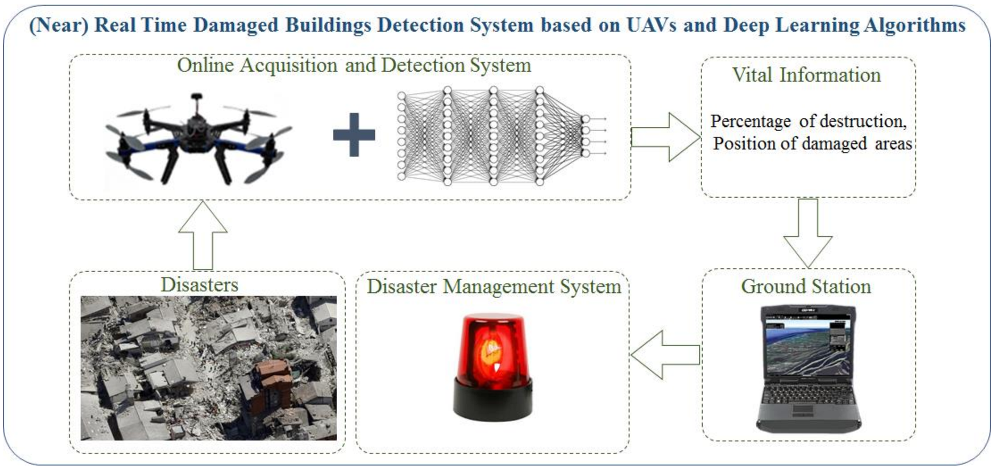
Fatemeh Alidoost[(1)] , Hossein Arefi[(1)]

[(1)] *School of Surveying and Geospatial Engineering, College of Engineering, University of Tehran, Tehran, Iran, (falidoost, hossein.arefi)@ut.ac.ir*

Key-Words: DeepEye; Deep Learning; CNNs; Building Detection; Disaster.

ABSTRACT:

Each year, natural crisis and disasters such as earthquakes, landslides, flood and typhoon impact broad areas of the world especially residential areas and man-made structures like buildings. In order to decrease the negative social and economic impacts of such events, accessibility to (near) real time and accurate geospatial information of degraded areas is so vital at early stages. In this study, an autonomous and knowledge based approach is proposed using the power of deep learning algorithms to detect damaged buildings from acquired images by Unmanned Aerial vehicles (UAVs). This structure is called DeepEye which it is utilized the Convolutional Neural Networks (CNNs) to fast analysis as well as automatic interpretation of aerial images (Figure 1). The CNN is a kind of feed-forward neural network with the multilayer perceptron concept which consists of a number of convolutional and subsampling layers in an adaptable structure and it is widely used in pattern recognition and object detection application. The major steps of proposed framework include the off-line library generation, off-line model training, online image segmentation, online damaged building detection and interpretation in order to calculate accurate locations as well as the percentage of degraded areas. In this framework, aerial images, captured by UAVs, are used to generate the candidate regions. Then, these image patches are fed into a fine-tuned CNN and a vector of highly distinguishable features are created to classify image patches into damaged and non-damaged buildings' classes. The assessment results prove the effectiveness of the proposed method to have an automatic and low cost recognition system which it could be critically useful to gather a lot of information from degraded areas in a short period of time in emergency response and disaster management applications.



DeepEye: a real (near) time damaged building detection system based on UAVs and deep learning algorithms

THE MAPP PLATFORM: REMOTE SENSING FOR AGRICULTURE BASED ON SATELLITE AND DRONE DATA

Vasco Pimenta[(1)]

[(1)] *Spinworks, Portugal, vasco.pimenta@spinworks.pt*

Key-Words: MAPP platform, NDVI, farm manager.

ABSTRACT:

Remote sensing has been increasingly used in the agricultural sector in recent decades and has become a key tool for monitoring and managing crops. Using images captured at different wavelengths it is possible to calculate a set of vegetation indices that allow evaluating the relative density and vegetative vigour of plants, the Normalized Difference Vegetation Index (NDVI) being one of the most popular. Essentially based on satellite imagery, remote sensing for agriculture has gained prominence in recent years with the complementary capture of high-resolution images at competitive prices, through UAV systems, commonly known as drones.

Based on previous experience in the space sector, Spin.Works has developed the S20 platform, a fixed-wing micro-drone system, focused to high productivity (> 1000 ha / day / Drone), specifically designed for remote sensing applications for large extensions. In addition, Spin.Works has developed MAPP (mapp.spinworks.pt), a web application to provide remote sensing information captured from satellite and drone, as well as a set of tools capable of processing and manipulating this information, turning the data into knowledge actionable by experts and farm management.

NDVI maps calculated from high spatial resolution NIR images are extremely rich (<5 cm / pixel) compared to those obtained through satellite imagery, although the latter are available with higher temporal resolution and at a lower cost. However, while better resolution allows for a more concise analysis of the index, the presence of other elements such as dirt roads, vegetation between vine rows, groves and others is also emphasized. Accurate reading of the vineyard NDVI values thus necessitates the isolation of "plant pixels" from the background through a process of segmentation. Spin.Works has developed a set of segmentation techniques and algorithms integrated in its software that enables the automation of these processes.

With this information at the plant level, further processing is possible, enabling several other metrics according to the objectives of the farm manager. As an example, a zoning plugin allows the user to group plants based on user-defined NDVI intervals, allowing the identification of groups for differentiated intervention or for selective harvesting. With vine rows identified through segmentation, it is also possible to quantify and generate an intra-row vine gap map, with an estimate of the number of vines that can be replanted in each plot.

The vine segmentation process based on the described techniques can be applied at the parcel level, or using additional characteristics known for a particular vineyard, such as for red or white grapes, or filtered by one or more specific grape varieties that are intended to be vinified together. These techniques are automated and therefore scalable to the size of entire farms, regardless of their size.

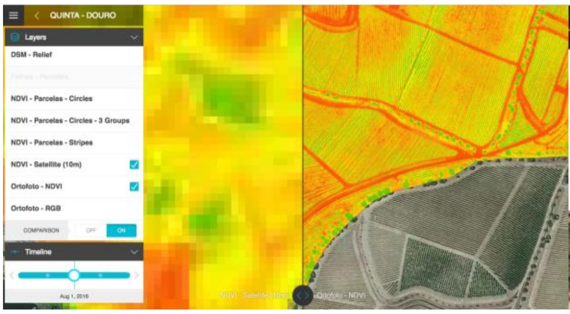


Figure 1 – NDVI index obtained from satellite (10 m/pixel) and drone (5 cm/pixel)

Figure 2 – NDVI at plant level, three groups, with productivity targets of 10, 30 and 20 hl respectively

The MAPP platform has been developed to ensure compatibility with mobile platforms, allowing direct use on site, taking advantage of their inherent geolocation capability. The platform integrates a set of visualization and analysis tools offering the user the flexibility to browse through historical data produced over several campaigns – according to his management strategy – allowing him to program a multiplicity of actions in different stages of the cropping season, such as anticipating interventions in areas affected by disease or with less vegetative vigour, considering selective pruning operations or the optimization of different irrigation zones, selective or delayed harvesting, mitigation and risk assessment in areas identified as most susceptible to landslides, or the application of fertilizers or micro-nutrients in a differentiated way with the aim of mitigating intra-parcel variability.

UAVS - REGULATIONS AND LAW ENFORCEMENT

Arthur P. Cracknell [(1)]

[(1)] University of Dundee, Scotland, apcracknell774787@yahoo.co.uk

Key-Words: MAPP platform, NDVI, farm manager.

ABSTRACT:

This is a sequel to the talk that I gave at last year's conference in Worcester. A lot has happened since then. Generally speaking there have been some developments in the regulations in various countries and there are a considerable number of examples of convictions and fines levied for dangerous or illegal operation of a UAV. There will be some general discussion of the requirements that must be satisfied if you are operating a UAV "for profit", which includes research activities or environmental monitoring in a university, research institute, etc. The training is expensive and time consuming, somewhere in between that for a driving licence for a car and a pilot's licence for a manned aircraft. Even if you are operating a UAV as a hobbyist there are still rules to ne observed although no training is required. The question of the registration of all drones that one possesses is a live issue in various countries.

I hope that, like last year, the talk will lead do a lively discussion amongst participants.