Vegetation structure from a fixed wing UAV system over peatland feature types

Degraded peatlands are important reserves of terrestrial carbon and their conservation is a major area of research. Monitoring is crucial to judge the success of this restoration. Aerial surveys are valuable tools for habitat mapping and conservation and provide useful insights into their condition. An autonomous, unmanned, aerial, remote sensing platform, QuestUAV 300™, was used to collect spectral aerial imagery over Moor House – Upper Teesdale National Nature Reserve. Using Agisoft Photoscan software, the imagery were stitched together into mosaics, georeferenced, and used to classify vegetation and peatland features. A classification of peatbog feature types was developed. These mosaics will be used to monitor changes in meso-scale habitat features and native plant species extents, as well as delineate different types of peatlands for conservation management. The UAV system was able to collect georeferenced imagery and was relatively straightforward to deploy in such a remote and unimproved area. The performance of the autonomous control system and the quality of the progressive-scan imagery indicated strong promise for future UAVs as useful field monitoring tools. Work is ongoing to further develop methods for mapping habitat extent and condition from UAV imagery, as an alternative to traditional field survey for use in the Centre for Ecology and Hydrology’s Countryside Survey – a UK wide monitoring programme.
Using UAV imagery and geostatistical analysis to quantify structural differences between unimproved and intensively managed grasslands

Since the 1960’s land management policy has encouraged the drainage of large areas of land for agricultural intensification. Consequently, semi-natural wet grasslands, such as Culm in SW England have seen a significant reduction in their spatial extent.

It is believed that the restoration of Culm grassland could deliver multiple benefits for water and soil resources in South West England. Ecosystem services, provided by Culm grasslands might include improved water storage, cleaner water, enhanced carbon storage and improved biodiversity. However, there is currently a lack of quantitative understanding of Culm grasslands. This study seeks to increase understanding of the structure and function of Culm grasslands and in so doing, will establish a solid knowledge base, from which management of these critical landscapes can progress.

A fixed wing UAV, equipped with a digital camera was flown over Culm and intensively managed grassland sites, with imagery processed to create structure from motion models. Soil surface properties were also quantified using a nested geostatistical sampling strategy. Results will be presented showing that the transition from semi-natural wet, to intensively managed grasslands results in a significant change in ecosystem structure, with important implications for water and soil resources.
Detecting Past Human Impact in the Amazonian Rainforest using UAV-mounted LIDAR and Spectral Remote Sensing

In order to characterize and quantify the extent of pre-Columbian human-modified forests, we will use a combination of multi-scale remote sensing information including: (1) a novel concept of very high resolution multi-spectral and Light Detection and Ranging (LIDAR) data from sensors mounted onboard of an UAV; (2) high spatial resolution Landsat data (30m spatial resolution); (3) high temporal resolution Moderate Resolution Imaging Spectroradiometer (MODIS) data (250-500 m spatial resolution). Plot specific spectral and structural features will be retrieved using the UAV in a scale directly comparable with the field data. The proof of concept will be developed with the support of INPE (National Institute for Space Research of Brazil) using the unmanned platform Microdrone (MD4-1000) quadricopter equipped with a multi-spectral camera (TetraCAM Mini MCA6) for data collection in the visible and near-infrared wavelengths and the Ibeo Lux Laser Scanner for the LIDAR acquisitions. Spectral and structural forest data collect by the UAV will be used in conjunction with Landsat spectral signatures allowing the extrapolation of plot features to the landscape level. The design of the field plots encompassing areas with a known history of pre-Columbian anthropogenic disturbance and areas without human interference will provide a basis for evaluating changes in the spectral and structural variables. The UAV system will provide unique very high resolution information that is crucial for this type of analysis, to avoid the mixing of targets inherent of lower resolution sensors.
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A Dual-Field-of-View Visible Near-InfraRed Reflectance and Fluorescence Spectrometer System for Logging and Unmanned Aerial Vehicle Applications

We present the design and preliminary field and laboratory performance characteristics of a light weight dual-field-of-view spectrometer system for the near simultaneous measurement of both reflectance and SIF from UAV platforms. This system utilises a double bifurcated fibre optic incorporating a novel switching mechanism such that it enables reflectance and SIF to be measured simultaneously from the same Earth surface area and reference irradiance to be measured at frequencies greater than 1Hz. This system is light weight, self-contained, and wirelessly controlled to enable it to be deployed on rotary-wing UAVs, as well as used for fixed location high temporal frequency logging measurement approaches. It contains the latest very high resolution Ocean Optics QE Pro optical bench which enables both O2 bands to be measured simultaneously and with the same integration time and a standard Ocean Optics USB2000+ optical bench. These near ground reflectance and fluorescence measurements are required to assess the sensitivity of SIF to changes in photosynthetic activity at spatial (leaf and canopy) and temporal scales, scales at which biogeochemical processes and ecosystem functional properties are already being assessed by other means in carbon flux observation networks. The use of UAVs and these measurements will also be necessary to validate observations from airborne sensors such as HyPlant and future space-based observationalb such as those from the ESA FLEX candidate mission.
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The HYUAV: a novel UAV-based spectroscopy tool for environmental monitoring

The objective of the present contribution concerns the development and preliminary testing of a novel UAV-based non-imaging hyperspectral system (HYUAV) for collecting near range Earth reflected radiance in the VNIR domain coupled with RGB images.

The optical payload comprises the Ocean Optics spectrometer which features a 1.5 nm FWHM (Full Width at Half Maximum) covering the 350 to 1000 nm spectral range and the RGB camera (Canon S100). A custom designed spectrometer entrance fore-optics was assembled to: i) reduce the USB4000 IFOV providing 1 m sampled area from a flight height of 10 m; ii) hold the neutral-density filter (transmittance 40%) avoiding saturation for high light levels; iii) hold a shutter allowing a regular in-flight dark-current measurements. The Anteos UAV platform (Aermatica S.p.A., Italy) is a small four-rotor with hovering capability, a maximum payload of 2 Kg and flight time of 20 min. A dedicated software application was developed: i) combining flight path and spectral measurements planning; ii) matching the hyperspectral data and the RGB images with the UAV navigation data to geolocated the optical data.

The HYUAV was tested in laboratory to assess the impact of platform vibrations to the USB4000 spectral (i.e. shift and band broadening) and radiometric stability. The capability to collect reflectance signatures of different land cover type (i.e. grassland, asphalt, roofs and inland water) was assessed during field campaign comparing HYUAV data to ground based ASD FieldSpec measurements.
Utilising a modified UAV platform for canopy assessment in an isolated mid altitude rainforest environment on Mount Mabu, Mozambique, Africa

In recent years, scientists from Kew and a number of other conservation organisations have undertaken the first intensive studies of Africa’s largest mid altitude rainforest on Mount Mabu. These studies have yielded significant discoveries in terms of biodiversity density, including a number of new species endemic to the region and other significant populations of globally threatened species. As a result of long term isolation, the rainforest is widely regarded by the scientific community as being in pristine condition. Initially scientists used Google maps to identify the region which has resulted in naming it the “Google Forest.” The most fertile regions of Mozambique which have high agro–ecological potential lie to the north of the mountain ridge indicating significance in the need to quantify the role of the mid-altitude rainforest biodiversity in terms of ecosystems functions and services. Utilising a low cost hybrid multicopter UAV platform at low altitude incorporating high bit depth and bi-spectral near IR cameras at a low pixel resolution could generate significant foliage digital surface models and visual datasets for a range of comparative analyses. Alongside the initial critical mapping of baseline data in the region, camera data can generate datasets of canopy cover and characteristics such as normalised difference vegetation index. Although the relationship between presence of endemic species is critical in quantifying biodiversity, the significance in terms of the neighbouring region to the north having the ability to produce an agricultural surplus, is critical in terms of long term stability of food supply.
Capturing the city landscape using UAVs

Capturing and visualizing the current view of the city opens up possibilities for a more complete understanding of the environment we live in, leading towards a participatory and sustainable planning process. The Bartlett Centre for Advanced Spatial Analysis, the Bartlett Development Planning Unit and the Swiss NGO Drone Adventures, joined local partners in Lima to map two case study areas of Barrios Altos and José Carlos Mariátegui. Communities from Lima engaged in a mapping expedition using cutting edge technologies such as mapping UAVs, to explore new innovative 3D mapping pathways for areas that are undergoing an otherwise 'invisible' change.

The UAVs outputs of the two areas were made available online aiding in raising awareness around environmental, social and planning issues. High Resolution Aerial photos shot with a Sensefly eBee UAV, were made available in OpenStreetMap for tracing with more than 3/4 of the area being mapped within the first 3 days of the release. Moreover, UAV’s 3D pointclouds were sent remotely to London from Lima to be 3D printed. The aim is to create an installation suitable for community planning purposes in the two areas.

We are working towards the development of a 3D online mapping platform that will allow communities to input their own voice regarding the future of their city, and will improve communication between different decision making parties, for a more sustainable urban.
RPAS Legislation - what can and can't be done in the UK and when flying becomes aerial work

UAV technology is becoming increasingly accessible to the general public, both in terms of cost and ease operation. New and innovative applications seem to surface almost daily. As a result we are currently experiencing one of the biggest changes in airspace use in aviation history. Fortunately, the UK Civil Aviation Authority (CAA) has been very forward-thinking and, rather than imposing a blanket ban on commercial use as the FAA has done in the US, has put legislation in place to begin to integrate UAVs into UK airspace. Legislation across Europe is currently inconsistent so the European Aviation Safety Agency (EASA) is also consulting on cross-Europe policies. This talk will introduce the UK legislation and highlight safe use and potential pitfalls when using UAVs both commercially and for research purposes.
UASs for Plant biosecurity and Plant Pest Detection and Surveillance: Challenges and Opportunities

This paper provides a qualitative evaluation of Unmanned Aircraft Systems (UAS) and on-board sensor technology for use in plant biosecurity. The focus is to identify how and under what circumstances UAS may be useful for plant biosecurity. This can be used to help guide future decisions regarding investment in UAS for plant biosecurity. The paper first identifies some high priority threats in biosecurity, namely those affecting broad acre cereal crops such as wheat, barley and oats. From a post-incursion stand point, early in-field pest detection, localisation, mapping, monitoring/surveillance and severity estimation represent a major part of the plant biosecurity process. From a pre-incursion stand point, interception of potential threats is key in the biosecurity context. UAS classes, performance characteristics and regulatory issues that govern their access to the national airspace are introduced. This results in a series of important considerations when selecting or designing UAS to be used in biosecurity applications. Sensors capable of detecting biosecurity threats in various stages of their lifecycle are introduced including spore traps, acoustic sensors and electromagnetic imaging devices. They can provide information on pre and post infection crop status to help discriminate healthy and unhealthy crop regions or to prevent an outbreak or spread of potential threats. A technology survey to help match the appropriate sensor and platform configuration to a specific biosecurity task is provided. A series of key points and recommendations on benefits UAS to the broader plant biosecurity community are also presented.
The use of UAV generated photo mosaic surveys for geological and geomorphological monitoring and mapping on the Jurassic Coast.

The application of UAV generated photography has been applied to two different sites within the Undercliffs National Nature Reserve between Lyme Regis and Axmouth, on the Jurassic Coast World Heritage Site. The first is on Monmouth Beach west of Lyme. Here, observations over a number of years highlighted sudden, spectacular and unexpected failure of the foreshore ledges, particularly in the calmer summer and early autumn weather. The aim of the UAV survey was to provide, in places, very high resolution (up to 2mm in places) photography to capture details including jointing and to provide a baseline map against which to measure future change. The second survey was undertaken further into the Undercliffs with the purpose of generating a high resolution (12mm) baseline photo mosaic to enable very detailed mapping of geological and geomorphological features. The foreshore in front of the Plateau landslide is a dissected rotational landslide complex that has not been mapped in detail to date. The stratigraphy largely remains in place albeit within a boulder obscured foreshore but the high resolution of the UAV photography has enabled mapping of small outcrops, less than 30cm in size. Collectively they are helping to explain the form of the massive, prehistoric landslide complex. The photography for both surveys was captured by Suave Aerial Photographers who supplied it as georectified images using Photosynth. Funding for the project was provided by Natural England. The photography has been integrated with the Channel Coast Observatory Strategic Monitoring Programme. Publication of results awaits further field work.
Systematic vertical error in UAV-derived topographic models: Origins and solutions

UAVs equipped with consumer cameras are increasingly being used to produce high resolution digital elevation models (DEMs). However, although such DEMs may achieve centimetric detail, they can also display broad-scale systematic deformation expressed as a vertical ‘doming’. This error reflects a combination of inaccurate description of radial lens distortion and the use of imagery captured in near-parallel viewing directions.

We show that for image networks with dominantly parallel viewing directions, self-calibrating bundle adjustment will not derive radial lens distortion accurately, resulting in associated systematic ‘doming’ DEM deformation. We illustrate the sensitivity of this effect to variations in camera angle and flight height. Deformation will be reduced if suitable control points can be included within the bundle adjustment, but residual systematic vertical error may remain, accommodated by the estimated precision of the control measurements.

Doming bias can be minimised by the inclusion of inclined images within the image set, for example, images collected during gently banked turns of a fixed-wing UAV or, if camera inclination can be altered, by just a few more oblique images with a rotor-based UAV. We provide practical flight plan solutions that, in the absence of control points, demonstrate a reduction in systematic DEM error by more than two orders of magnitude. We also illustrate how the doming effect can be minimised in existing image sets.
Potential of UAVs for water quality management

Near-shore aquaculture installations are subject to a range of biological threats from the advective transport of harmful micro- and macro-algae and jellyfish, and losses can have significant financial implications. Mitigation of the effects of these organisms is difficult, hence management is best achieved by early warning through monitoring.

In situ water sampling is applicable at a spatial scale of ~1 m and is generally assumed to be representative of a much larger area. Satellite remote sensing data from operational sensors is applicable at much larger spatial scales, e.g. 1 km. Between these extremes lie many important water quality applications, e.g. coastal aquaculture farms. Unmanned Aerial Vehicles (UAVs) have the potential to fill this gap, allowing cost effective monitoring of water quality at metre to kilometre scales.

With suitable in situ validation, simple algorithms exploiting ratios of visible bands can be used to estimate water quality parameters using RGB images from cheap off-the-shelf cameras mounted on UAVs. The most likely obstacle to this approach is the presence of surface reflections (sunglint and reflected sky light) within the image data. We present a method of correcting for reflected light in images collected using a twin camera system, where one camera has a NIR filter, to give a total of four bands. Reflected light is identified in the NIR and removed from the visible bands before water quality parameters are estimated from band ratios. We will present some example results from this approach and discuss its potential for monitoring water quality.
Detecting onshore impacts of wave power devices: mapping intertidal rocky shores with remotely piloted aircraft

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The basic methods for sampling rocky shore communities have not changed for many decades. Most surveys are variations on transect-based and/or stratified random sampling of quadrats whose scales and spatial arrangement are determined by the capabilities of the observer. The primary goal is to provide estimates of abundance of assessed species that are representative of the whole shore, based on statistical assumptions. Here I present the results of an alternative approach using multiple images taken by a camera mounted on a low-flying remotely piloted aircraft, flying a pre-programmed flight path. Three locations in the Outer Hebrides were surveyed in June 2013 as part of the pre-deployment phase of a study to assess the effects of an array of nearshore wave-energy extraction devices. Ground-based low-tide surveys were made using categorical abundance and quadrat-based estimation of abundance of conspicuous cover-forming species. Overflights were made at the same time using a 1.5m-wingspan Quest 200 UAV at 30m altitude, equipped with a Panasonic LX5 camera taking images every 2s. Flights lasted up to 25 minutes and returned 150-200 overlapping GPS-located images of the target area. Photogrammetry software allowed the production of ortho-photographs and digital elevation models (DEMs) of areas extending 400-700m along the coast and 70-100m from low to high shore. The orthophotos and DEMs had resolution of 1.5cm and 5cm respectively. This resolution showed individual fucoid plants and other macroalgae, notably Enteromorpha intestinalis, and the quality of the images permitted the distinction between areas dominated by newly settled and older barnacles (mostly Semibalanus balanoides). Supervised pixel classification on downscaled (5-cm) images gave moderately successful recognition of six types of substratum cover. The results of the aerial and ground-based surveys were compared, and the relative merits of each were assessed. Aerial methods are not likely to replace ground surveys soon, but they allow scaling up from quadrat-based estimates with an unprecedented level of confidence, and are likely to play an increasingly important role in the development of rocky shore ecology in the 21st century.

Key words: aerial photography, mapping, rocky shores, wave energy
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Seals, RPAs and surveys

The task of providing information on the status of seal populations around the UK is one which the Sea Mammal Research Unit, based in St Andrews, has traditionally carried out by synoptic survey aerial surveys. Fixed wing or helicopter flights at specific times of year are used to produce counts at particular stages in the seals' annual cycle.

We can now add small scale surveying using RPA to the suite of techniques available. In the last 2 years we have carried out trial flights to survey grey and harbour seals at a number of sites in Scotland. The platform we use allows low disturbance approaches and image acquisition to give counts, age/sex categorisation and high resolution photos to the point where individual identity by photo-id is possible.

RPAs offer a highly versatile and novel way of obtaining survey data, but there are limitations and some of these, from the legal to the practical will be discussed.