Modern sensors and airborne remote sensing for mapping of vegetation and hydromorphology along Federal waterways in Germany

mDRONES4rivers

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Overview

Up-to-date information about vegetation types and hydromorphological structures and features are essential for the management of waterways. They are e.g. used for the monitoring and reporting of riparian statuses and their changes e.g. after river restoration and consequently, numerous man-days are spent on field surveys. To allow for an effective survey of vegetation and hydromorphology in large or even inaccessible areas, a data acquisition and processing workflow is being developed complementing in-situ methods with remote sensing techniques.

Aerial surveys by unmanned aerial systems (UAS) and a gyrocopter are combined with ground measurements of hyperspectral reflectance signatures as well as with field mapping of vegetation types and hydromorphological structures and features. The remote sensing data is classified with an object based image analysis and classification algorithm. The mobile and at three sites continuous measurements of hyperspectral field data and the typical field surveys provide data for calibration. Contrary to other approaches that focus on what can be detected and classified with certain sensor systems and datasets, the project addresses equally the user needs to obtain certain classes for monitoring and reporting.

The intended results are (i) data acquisition, correction and classification workflow combining remote sensing and field data, identification and change detection (ii) of important vegetation and biotope types and (iii) of hydromorphological structures and substrate as well as indicators necessary for the evaluation of the hydromorphological quality. The preliminary results to be presented include datasets from UAS, gyrocopter, and field surveys, an outline of processing workflow and classification algorithm based on Python scripts and eCognition software and first vegetation and hydromorphological classification results from spring and summer datasets.

UAS
high resolution
multispectral

Gyrocopter
large scale
sensor development

multitemporal

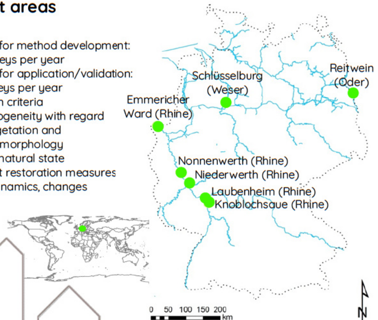
GOBIA & classification
user oriented
as detailed as possible
combined with in situ surveys
> Status monitoring
& change detection

Hyperspectral reference
incl. long-term measurements

Ground truth
- hydromorphology
- vegetation
- georeference

Project areas

- 5 areas for method development: 3-4 surveys per year
- 2 areas for application/validation: 1-2 surveys per year
- Selection criteria
  - heterogeneity with regard to vegetation and hydromorphology
  - near-natural state
  - recent restoration measures >> dynamics, changes

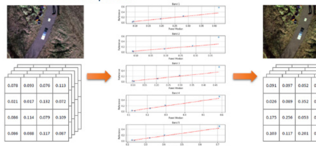


Unmanned aerial systems

Aims
- Multispectral imagery (RGB, RE, NIR; 3-4cm/px)
- High resolution RGB (2cm/px)
- Digital surface models
- High geometric & radiometric accuracy

Objectives
- Georeferencing, real time kinematic (RTK)
- Atmospheric correction based on a Downwelling Light Sensor (DLS)
- Empirical line correction based on calibrated reflectance panels

Data acquisition with MAVinci Intel Sirius Pro with the FujiX-M1 and RTK (> HR RGB)(left) and DJI Phantom 4 Pro with the Micasense RedEdge M (> multispectral imagery)(right).



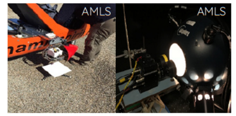
Images of the calibrated reflectance panels and examples of the empirical line correction applied to the multispectral imagery.

Gyrocopter

Aims
- Medium scale multispectral imagery (RGB, NIR; 15-30cm/px)
- Digital surface models
- High geometric and radiometric accuracy

Objectives
- Georeferencing, post processing kinematic (PPK)
- Radiometric correction based on calibrated reflectance panels
- Flat field correction (Ulbricht sphere)

Sensor management system with multispectral camera and gimbal for permanently nadir viewing angle (left) and mounted on the gyrocopter (right).



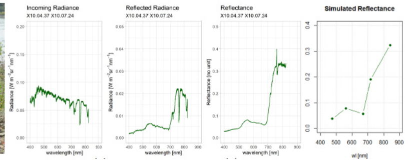
Calibration based on reflectance panels before flight (left) and measurements for flat field correction with the integrating sphere in the laboratory (right).

Field spectroscopy

Aims
- Spectral library of project relevant land surface classes
- Optimization of band combinations
- Evaluate the ability to differentiate between classes

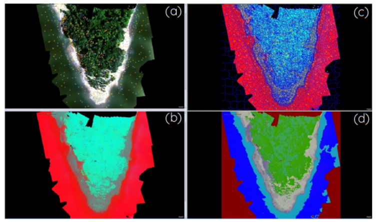
Objectives
- In situ hyperspectral measurement during the field surveys (400-830nm, FWHM ~1.5nm)
- Continuous measurements (3 locations)
- Developing a sensor simulator for future band selection
- Updating and analyzing the spectral library

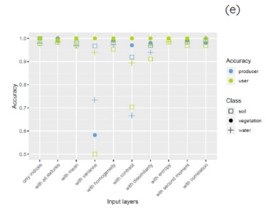
Permanent hyperspectral reflectance measurements over water, substrate or pioneer species (depending on the season) in Emmerich (left) and example of mobile measurements during the field survey (right).



Mobile hyperspectral measurements of a young meadow with incoming and reflected radiance, as well as calculated reflectance (left) and the reflectances calculated with a sensor simulator based on the specifications of the multispectral bands.

OBIA & classification



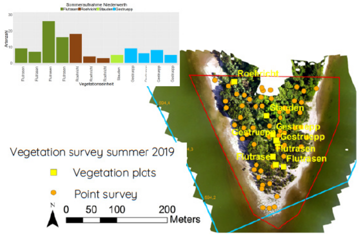


Example of a multiresolution segmentation and basic classification with the support vector machine classifier of water, vegetation and soil surface in the project area Niederwerth (a). The input layers so far consist of band indices (NDVI, NDRE, NDWI, SAVI) (b) and surface texture parameters, that are divided into object with a multiresolution segmentation algorithm (c) and then classified based on the available ground survey data (d). Several classification algorithms and input layer combinations (e, support vector machine classifier) are being tested.

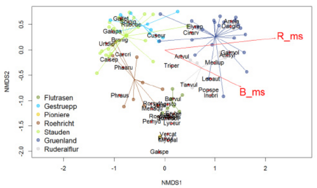
Vegetation

Aims
- Monitoring of vegetation (low cost, objectively)
- Characterization of habitats
- Assessment from a nature conservation perspective

Objectives
- Identification of vegetation units and biotope types
- Probability of occurrence of vegetation units and dominant species
- Identify habitat heterogeneity, complexity and environmental variables
- Identification of habitats and species deserving protection



Example of the vegetation survey in the project area Niederwerth. Points represent punctual identification of species and their vegetation unit to train and validate remote sensing imagery. Squares represent a detailed vegetation survey within 16 m² plots where all species within and their percentage coverage were documented for species based analysis of the imagery.



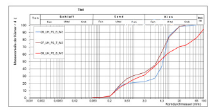
Non-metric multidimensional scaling (NMDS) based on plot observations to identify dissimilarities between vegetation units as well to analyze the relation of dominant and indicator species to vegetation units and to spectral gradients.

Hydromorphology

Aims
- Detailed hydromorphological surveying and mapping
- Reduce field surveys and improve survey quality (objectivity)
- Transfer to different survey areas
- Relationship to biotopes and habitats

Objectives
- Identification of substrates and structures
- Semiautomatic classification and mapping methods
- Implementation into existing evaluation procedures

Examples of hydromorphological structures visible in the multispectral mosaic (RGB, 3.1cm/px) and in the photo documentation and GPS measurements during the ground survey.



Surface substrate samples along a lateral transect and the corresponding grain-size distribution curves.

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