Publications of the Institute of Geophysics, Polish Academy of Sciences
Geophysical Data Bases, Processing and Instrumentation
vol. 439 (E-12), 2022, pp. 35-37
DOI: 10.25171/InstGeoph_PAS_Publs-2022-011
Webinar on Methods for Ecohydraulics: Remote Sensing, 17–20 May 2022

Mapping Riparian Vegetation and Hydromorphology with UAS and Machine Learning

Björn BASCHEK[1,✉], Edvinas ROMMEL[1], Frederik KATHÖFER[1], Laura GIESE[1], Katharina FRICKE[1], Tina MÖLTER[2], Filip DZUNIC[2], Maryam ASGARI[3], Paul NÄTHE[4], Paul DEFFERT[2], Rock GILLES[2], Jens BONGARTZ[3], Andreas BURKART[4], Maike HEUNER[1], Ina QUICK[1], and Uwe SCHRÖDER[1]

[1]Federal Institute of Hydrology, Koblenz, Germany

[2]Geocoptix, Trier, Germany

[3]University of Applied Sciences, Koblenz, Germany

[4]JB Hyperspectral Devices, Düsseldorf, Germany

✉ mdrones4rivers@bafg.de

Abstract

Sustainable management of riparian zones requires detailed spatial information about vegetation and hydromorphological properties. Uncrewed aerial systems (UAS) or gyrocopters equipped with multispectral cameras yield imagery of small to intermediate scale areas. Machine learning classification workflows (object based, random forest) including additional geodata and trained with in-situ data allow to map classes of vegetation and hydromorphological substrate types with different level of detail. A case study was carried out in a floodplain area along the River Rhine, Germany, resulting in overall accuracies for UAS data of 89% for basic surface types, 88% for vegetation units, 75% for dominant stand, and 62% for substrate types. Classification probability maps helped to identify areas of lower classification performance, as e.g. vegetation within the transition zone, thus allowing for a subsequent, more focused and effective site inspection. In combination, this workflow provides a valuable tool for monitoring and ecologically integrated water management.

Keywords: floodplain vegetation, river, remote sensing, OBIA, classification.

1. INTRODUCTION

River floodplains are hotspots of biodiversity and at the same time affected by human activities, especially along regulated waterways used for transportation. Flooding and water availability drive the small-scale distribution of vegetation communities.

A sustainable management of waterways requires sufficient data on vegetation and hydromorphological substrate types and structures. Though numerous person-days are spent on field surveys, spatial data is often insufficient, in particular in inaccessible areas. Imagery acquired by uncrewed aerial systems (UAS) in combination with suitable processing algorithms can be an efficient tool to gain information about ecosystems and to reduce time spent on in-situ data acquisition to a minimum.

The joined research project “mDRONES4rivers” had the aim to fine-tune data acquisition methods for river floodplains in Germany. Using as an example the nature reserve Emmericher Ward, Rhine River, Germany, this case study proposes a classification framework for UAS or gyrocopter imagery focusing on vegetation units and outlines a combined mapping approach with UAS or gyrocopter and field data.

More detailed background information on related literature, methodology and results can be found in Rommel et. al. (2022).

2. METHODOLOGY

Multiple indices and texture measurements were calculated based on 5 cm resolution, multispectral UAS imagery (red, green, blue, red-edge, near infrared; MicaSense RedEdge-M on a DJI Phantom 4 Pro UAS). Alongside this data a flood duration model and a digital surface model were used to apply an object-based image analysis (OBIA) workflow. Processing steps included segmentation, feature selection, hyperparameter tuning, model fitting, and evaluation.

Following segmentation, basic surface types were classified, distinguishing between vegetated areas, substrate types and water (6 classes, 1st level). Based hereon, vegetation was further classified in units found in riparian zones (5 classes, 2nd level) and dominant stands (19 classes, 3rd level). In parallel, substrate types were divided into 7 classes, 2nd level. The classification was implemented using Random Forest (RF) algorithm with tuned hyperparameters for each level.

Training and validation of the classification models was performed based on in-situ data, which was collected parallel to flight survey and afterwards expanded by using processed orthophotos. Following a bootstrap approach 500 models were built with different combinations of training and validation data. Probability maps were produced by class membership probabilities automatically estimated within the RF classification.

3. RESULTS

High overall accuracies (OA) were achieved for basic surface types (OA = 89%) and vegetation units (OA = 88%). Dominant stand and substrate type classification resulted in OA of 75% and 62%. The results for dominant stands are species dependent. Especially in the case of strongly fragmented stands and not surprisingly for small training samples classification accuracies are low. However, for well-developed stands mostly formed by big species satisfactory results are achieved.

The proposed approach for future monitoring activities is to reduce the need of additional in-situ and in image training data by including existing data from similar riparian zone areas. For larger areas (up to 40 km²/h), gyrocopter can be used – though in that case more in-situ data for (pre-)training is required as producing additional training data from orthophotos is more difficult due to typically reduced resolution. By including auxiliary data and acquiring UAS or gyrocopter data, classification and probability maps are to be produced. By combining them as well as adding knowledge about achievable accuracies for individual target classes of classification and making them available in field on a handheld device, a concluding on-site investigation can be planned in an efficient way by putting focus, e.g. on areas of low performance probability but high user relevance.

Thus, our results provide a valuable step using robust machine learning algorithms to develop an efficient monitoring tool for applied water management.

Acknowledgments. The authors are thankful to the German Federal Ministry for Digital and Transport and the mFUND for funding the project mDRONES4rivers (FKZ: 19F2054).

References

Rommel, E., L. Giese, K. Fricke, F. Kathöfer, M. Heuner, T. Mölter, P. Deffert, M. Asgari, P. Näthe, F. Dzunic, G. Rock, J. Bongartz, A. Burkart, I. Quick, U. Schröder, and B. Baschek (2022), Very high-resolution imagery and machine learning for detailed mapping of riparian vegetation and substrate types, *Remote Sens.* **14**, 4, 954, DOI: 10.3390/rs14040954.

Data availability: https://zenodo.org/search?q=mDRONES4rivers

Received 9 May 2022
Accepted 16 May 2022