UAV Spectral Image Mapping of Shoreline Vegetation

Jitka Komarkova, Pavel Sedlak

Rapid identification of a clear water surface, shoreline and vegetation can serve as a means of monitoring of the water level and as an important indicator of changes. In cases when a high level of detail or on-demand data collection is required, unmanned aerial vehicles (UAVs or 'drones') can provide a good service. It is important to think about the costs of the UAV and the connected sensors as well. Multispectral and thermal cameras are still very expensive in comparison to visible cameras. This article shows how a commercially available middle-class drone (DJI Phantom 3 with built-in camera), which collects data only in the visible spectral bands and is affordable even for individuals, can be easily used to calculate colour spectral indices to identify shoreline, vegetation and water.

Area of Interest

An area lying to the north of the city Pardubice, the Czech Republic, is very rich in ponds and is close to the University of Pardubice. The area of interest is flat, lying approx. 220 m a.s.l. It covers clear water surface, seasonally flooded greenery, vegetation including treetops, dry reeds (including dry grass), and dry trees (see Figure 1).

Figure 1: Area of interest – shoreline of the pond Skrin

Flight Planning and Data Collection

Dataset was captured on April 20, 2018, i.e. in spring. The flight was planned in advance in DJI GO and then sent to drone. The drone automatically flew according to the plan. It took approximately 15 minutes to cover the area of 0.0285 km^2 so no break in the flight was necessary. The total length of the flight was 1545 m, it was planned in 7 main lines consisting of 64 waypoints in total. Both front and side overlap was 60 %. Average speed was 2.2 m/s, altitude 39.6 m, resolution 1.7 cm per pixel.

Data Processing – Calculation of Vegetation Indices Based on Visible Spectral Bands

Two software tools were used: Pix4Dmapper 4.2.27 trial and ArcGIS for Desktop 10.5.1. Pix4Dmapper was used for a mosaic building and all indices calculation. ArcGIS was used for visualization of resulting indices. WGS 84 – UTM zone 33N was used as a coordinate system.

The final mosaic was created from 33 images. It covers 0.012 km^2. Images showing only treetops were not aligned because of the lack of common points. So, this type of land cover requires a higher overlap. Yet, the final mosaic covered the whole shoreline so it was perfectly usable for the next step.

We calculated various colour-based vegetation indices, which are based only on red, green, and blue bands: CIVE, ExG, ExR, GRVI, NDI, TGI, VARI, and VDVI. Several colour bands combinations and combinations of particular indices were calculated as well to include different approaches described in a literature.

ArcGIS was used for visualization of the results as far as it provides more visualization methods and better tools for map creation. We used “Pink to YellowGreen Diverging, Bright” colour ramp for all indices, which helped us to visually distinguish between particular land cover types. The other settings were: stretched visualization, percent clip stretch (both min and max: 0.5). Green colour represents the highest values, dark pink represents the lowest values, and yellow represents medium values in all cases to ease a comparison of the results. An inverted scale would be more natural in some cases, e.g. for displaying vegetation with the green colour.

Results and Interpretation

Based on our visual interpretation and literature, the following colour indices were chosen as the most suitable ones: CIVE, ExG – ExR, NDI, Red/Green ratio, and VDVI (see Figure 2 for results and Figure 33 for calculating algorithms).

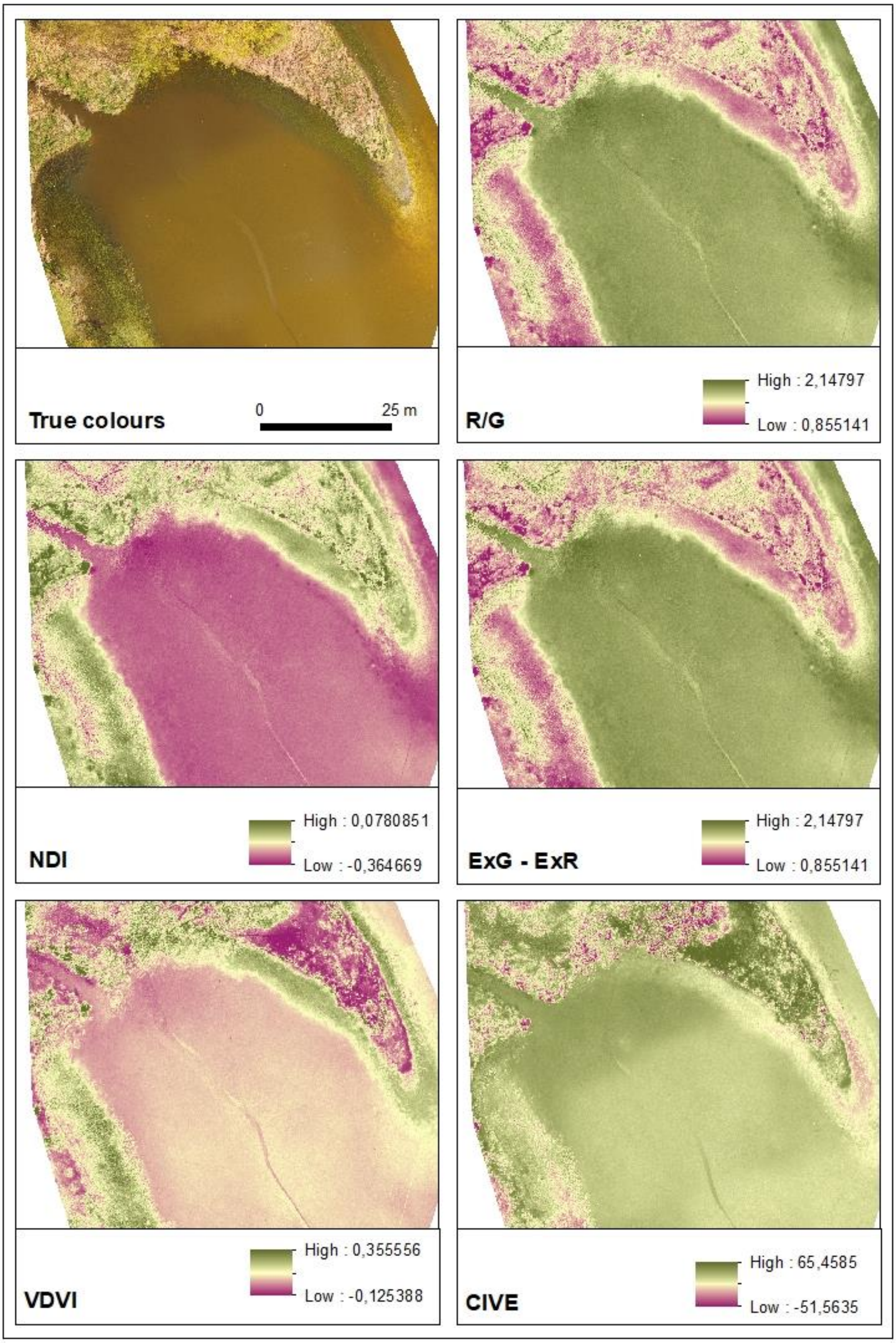

Figure 2: Area of interest and calculated vegetation indices

The clear water surface is highlighted by R/G, ExG – ExR (dark green in both cases), and NDI (dark pink). Water surface can be easily distinguished from the seasonally flooded greenery. The borderline between the clear water surface and seasonally flooded greenery is drawn by the yellow line.

Green vegetation is highlighted by all indices. VDVI and CIVE very well highlight treetops. They display green and dry vegetation in dark colours so these two types of land cover can be easily distinguished.

Seasonally flooded greenery is well visible with R/G, NDI, ExG – ExR, and VDVI because it is bordered by a yellow line. The best result is provided by VDVI (green colour).

Dry reeds and dry trees are well highlighted by VDVI (dark pink) and CIVE (dark green).

Comments to Indices

VDVI is very useful for differentiation green vegetation from dry vegetation.

R/G (and its opposite G/R) allows easily distinguishing between vegetation and the clear water surface.

ExG – ExR difference allows distinguishing all vegetation from the clear water surface.

NDI allows distinguishing all vegetation from the clear water surface.

CIVE well highlights green vegetation, which can be easily distinguished from dry vegetation (both trees and reeds). The clear water surface cannot be easily distinguished because it is visualized in a similar way as dry vegetation.

CIVE	Colour Index of Vegetation Extraction	0.441*Red – 0.81*Green + 0.385*Blue + 18.78745
ExG	Excess Green	2*g – r – b
ExR	Excess Red	1.3*r – g
NDI	Normalized Difference Index	(Green – Red)/(Green + Red)
VDVI	Visible-Band Difference Vegetation Index	(2*Green – Red – Blue)/(2*Green + Red + Blue)

Figure 3: Calculation formulas used to calculate vegetation indices

Conclusion

Shoreline, vegetation and the clear water surface can be easily monitored by a middle-class UAV equipped with the camera recording only in the visible spectral bands. It provides a very high spatial resolution data on demand and with acceptable costs. It can significantly help with monitoring of not easily accessible areas like overgrown or waterlogged areas as in our case. Particular land cover types can be easily distinguished by a visual interpretation as the first step. Vegetation indices based on visible spectral bands appropriately complement the visual interpretation. They can quickly highlight vegetation, seasonally flooded vegetation and the clear water surface so shoreline can be identified as well. Each index emphasizes different types of land cover so combination of more indices is beneficiary.

Acknowledgement

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Further Reading

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Jitka Komarkova works for the Institute of System Engineering and Informatics, Faculty of Economics and Administration, University of Pardubice, the Czech Republic as an Associate Professor and GIS specialist. She is major in usability of web-based GIS; and spatial data analyses.

Pavel Sedlak works for the Institute of System Engineering and Informatics, Faculty of Economics and Administration, University of Pardubice as a cartographer and GIS specialist. He is major in changes of landscape by remote sensing data; and usability in cartography.