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Assessing the Utility of Unmanned Aerial Vehicle-Borne Hyperspectral Image and Photogrammetry Derived 3D Data for Wetland Species Distribution Quick Mapping

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Abstract : Lightweight unmanned aerial vehicle (UAV) loading with novel sensors offers a low cost approach for data acquisition in complex environment. This study established a framework for applying UAV system in complex environment quick mapping and assessed the performance of UAV-based hyperspectral image and digital surface model (DSM) derived from photogrammetric point clouds for 13 species classification in wetland area Mai Po Inner Deep Bay Ramsar Site, Hong Kong. The study area was part of shallow bay with flat terrain and the major species including reedbed and four mangroves: Kandelia obovata, Aegiceras corniculatum, Acrostichum auerum and Acanthus ilicifolius. Other species involved in various graminaceous plants, tarbor, shrub and invasive species Mikania micrantha. In particular, invasive species climbed up to the mangrove canopy caused damage and morphology change which might increase species distinguishing difficulty. Hyperspectral images were acquired by Headwall Nano sensor with spectral range from 400nm to 1000nm and 0.06m spatial resolution image. A sequence of multi-view RGB images was captured with 0.02m spatial resolution and 75% overlap. Hyperspectral image was corrected for radiative and geometric distortion while high resolution RGB images were matched to generate maximum dense point clouds. Furtherly, a 5 cm grid digital surface model (DSM) was derived from dense point clouds. Multiple feature reduction methods were compared to identify the efficient method and to explore the significant spectral bands in distinguishing different species. Examined methods including stepwise discriminant analysis (DA), support vector machine (SVM) and minimum noise fraction (MNF) transformation. Subsequently, spectral subsets composed of the first 20 most importance bands extracted by SVM, DA and MNF, and multi-source subsets adding extra DSM to 20 spectrum bands were served as input in maximum likelihood classifier (MLC) and SVM classifier to compare the classification result. Classification results showed that feature reduction methods from best to worst are MNF transformation, DA and SVM. MNF transformation accuracy was even higher than all bands input result. Selected bands frequently laid along the green peak, red edge and near infrared. Additionally, DA found that chlorophyll absorption red band and yellow band were also important for species classification. In terms of 3D data, DSM enhanced the discriminant capacity among low plants, arbor and mangrove. Meanwhile, DSM largely reduced misclassification due to the shadow effect and morphological variation of inter-species. In respect to classifier, nonparametric SVM outperformed than MLC for high dimension and multi-source data in this study. SVM classifier tended to produce higher overall accuracy and reduce scattered patches although it costs more time than MLC. The best result was obtained by combining MNF components and DSM in SVM classifier. This study offered a precision species distribution survey solution for inaccessible wetland area with low cost of time and labour. In addition, findings relevant to the positive effect of DSM as well as spectral feature identification indicated that the utility of UAV-borne hyperspectral and photogrammetry deriving 3D data is promising in further research on wetland species such as bio-parameters modelling and biological invasion monitoring.

Keywords : digital surface model (DSM), feature reduction, hyperspectral, photogrammetric point cloud, species mapping, unmanned aerial vehicle (UAV)
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