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Seeing the forest for the trees: mapping cover and counting trees from aerial images of a mangrove forest using artificial intelligence

Mangrove forests are threatened by multiple anthropogenic stressors, urging researchers to create improved monitoring methods for their conservation and management. Recent remote sensing efforts have found some success using high resolution imagery of mangrove forests with sparse vegetation. In this study we focus on stands of mangrove forests with dense vegetation, consisting of the endemic Pelliciera rhizophorae and the more widespread Rhizophora mangle mangrove species, located in the remote Utria National Park in the Colombian Pacific coast. Our workflow used consumer-grade Unoccupied Aerial System (UAS) imagery of the mangrove forests, from which large orthophoto mosaics and digital elevation models are built. We apply convolutional neural networks (CNNs) for instance segmentation, to accurately delineate (33% AP) individual tree canopies for the Pelliciera rhizophorae species. We also apply neural networks to accurately identify (97% precision and 87% recall) the area coverage of the Rhizophora mangle mangrove tree species, as well as the area coverage of surrounding mud and water land-cover classes. We provide a novel algorithm for merging predicted instance segmentation tiles of trees, to recover tree shapes and sizes in overlapping and bordering regions of tiles. Using the segmented ground areas we interpolate their height from the digital elevation model to generate a digital terrain model, significantly reducing the effort for ground pixel selection. Finally, we calculate a canopy height model from the digital elevation and terrain models, and combine it with the inventory of Pelliciera rhizophorae trees to derive the height of each individual mangrove tree. The resulting inventory of mangrove trees, with individual P. rhizophorae tree height information, as well as crown shape and size descriptions, enables the use of allometric equations to calculate important monitoring metrics, such as above ground biomass and carbon stocks.

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