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An enhanced algorithm for co-registering individual trees extracted from airborne LiDAR and aerial photographs

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As fine-resolution remotely sensed data rapidly evolves, individual trees are increasingly becoming a prevailing unit of analysis in many scientific disciplines such as forestry, ecology, and urban planning. Fusion of airborne LiDAR and aerial photography is a promising means for improving the accuracy of individual tree mapping. However, local misalignments between these two datasets are frequently ignored. Solving this problem using traditional pixel-based image registration methods requires extensive computation and is extremely challenging on large scales. In our earlier research, we proposed an approach that involved determining the optimal offset vector for a local area and using it to rectify the spatial positions of all individual trees in that area. Although the approach is effective in addressing mismatch issues, it still exhibits large errors for some trees and is susceptible to changes in scale. Here, we propose an enhanced algorithm by constructing a data structure called a k-dimensional tree (also known as K-D Tree) to efficiently search for each tree's unique offset vector and assigning the closest determined offset vector to candidate trees that lack corresponding counterparts in the reference data. The enhanced algorithm significantly improves the matching accuracy of individual trees, elevating it from 0.861 ± 0.152 to 0.911 ± 0.126 ($p < 0.01$, *t*-test). Moreover, it substantially reduces the computational time by approximately 70% and successfully overcomes limitations associated with scale changes. The example data, source code, and instructions for the enhanced algorithm are publicly available on GitHub*.

*https://github.com/XUYIRS/Individual_trees_matching