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| **"Density × Volume": A non-Destructive Observation Technology of Tree aboveground Biomass** |
| As an indirect observation method, the tree anisotropic growth equation is prone to subjective errors, and the applicability of the equation varied in different environments, so this paper innovatively proposes a non-destructive observation technology of tree aboveground biomass of "density×volume". A multi-frequency microwave-based single-tree biomass density observation technology was proposed. Based on theoretical analysis and experimental measurement, microwave frequency applicable to different tree species and diameter level of woody plant density observation was explored. Then, by analyzing the changing laws of microwave characteristics, attenuation constants, aboveground biomass density, single-tree density observation model of different tree species was established, with an average error of 6%, accuracy of 94%, measurable diameter range of more than 60cm. By using height standardization of terrestrial and UAV LiDAR point cloud data, tree trunks were quickly detected by hierarchical clustering, and then multi-level distribution of individual trees was generated. For the clustered points of each level, the fast point feature histogram features were calculated, and then they were used to match the points of the distribution of the same level to obtain their transformation matrix, and finally through the iterative nearest point method, the further fine alignment was performed. The average goodness of fit obtained was 0.945, with an RMSE of 0.144. Using the single tree modelling approach, the branching patterns, geometric and volumetric characteristics of the trees were quantified, and the aboveground volumetric monitoring accuracy of the single trees reached 85%, with some species reaching more than 90%. Finally, the aboveground biomass of individual trees was calculated by multiplying the aboveground biomass density by the aboveground volume. |