Multisensor Drone Approaches to Forest Stand Volume Estimation in Steep, Challenging Terrains

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The need for accurate forest inventory data is becoming increasingly important for managing and conserving forests and sustainable resource use. It is particularly crucial in assessing carbon sequestration and others, such as preserving biodiversity. Yet, traditional field surveys, which remain essential, can be laborious, time-consuming, and especially tough in difficult terrains like those common in Japan.

Our study is situated in a coniferous plantation in Hanno City, Saitama Prefecture. With its steep average slope of 34 degrees, the area presents a challenge for forest management. To address these challenges, this study considers the potential of drone technology and related sensors, specifically utilizing LiDAR (Light Detection and Ranging), multispectral, and thermal data for temporal analysis.

Detailed topographic information and tree structure data were obtained using the Matrice 600 Pro and LiAir S50 system for LiDAR data collection. Simultaneous observation of multispectral and thermal data was achieved using the Matrice 300 and dual gimbal system, integrating the SlantRange 4P+ multispectral sensor and Zenmuse-XT2 thermal camera. Our data allowed us to compute indices such as the Normalized Difference Vegetation Index (NDVI) and Red Edge NDVI, alongside the extraction of absolute thermal imageries. These were processed using the Structure from Motion (SfM) technique to orthorectify and mosaic the images, providing an extensive view of the study area. This combination of data should contribute to an in-depth understanding of the tree's physiological function.

Combining data from multiple drone platforms and sensors gave us a rich dataset. We then used a Random Forest model to estimate the forest stand volume from this dataset. Alongside visualizing the data, we aim to find significant links between timber volume and various variables using ANOVA, the Kruskal-Wallis test, and Dunn’s test for pairwise comparison between each independent group. These groups were clustered into five classes based on different stem volume ranges. Ultimately, we will improve our methods for estimating stem volume at the stand level and explore tree growth rate using time-series data.

Our study shows how multi-sensor drone-based data can be used to estimate forest stand volume in challenging terrains. Our findings can offer valuable insights for enhancing forest management practices and promoting healthier, more sustainable forest ecosystems. The presentation will focus on our methodology, results, and what they mean for forestry and drone technology applications.

Keywords: drone, multispectral, thermal, machine learning, forest parameter