

Improving the model architecture could further boost prediction accuracy. Combining CNN feature extraction with Random Forest or Gradient Boosting, hybrid learning methods could offer more stable predictions. Adopting architectures like EfficientNet or Vision Transformers may enhance feature abstraction for diverse environments. Ensemble techniques, such as stacking or bagging, could help mitigate overfitting and improve robustness across varied carbon stock distributions.

IV. CONCLUSION

This study evaluated the effectiveness of VGG-16 and ResNet-20 in estimating carbon stock using drone imagery, with hyperparameter optimization conducted through Optuna and GridSearchCV. The results demonstrate that VGG-16 consistently outperformed ResNet-20, achieving the highest R^2 score of 0.645 with Optuna, highlighting its superior feature extraction capabilities in this context.

The study highlighted significant challenges, including issues with dataset imbalance and the difficulty in accurately predicting high-carbon stock values, which often leads to systematic underestimation. The findings suggest that addressing these challenges through advanced data augmentation, synthetic data generation, and multispectral or LiDAR data integration can enhance model robustness and generalization.

Future research should investigate hybrid approaches that combine deep learning with traditional machine learning techniques, such as Random Forest and Gradient Boosting, to improve predictive stability. Furthermore, exploring alternative architectures like EfficientNet and Vision Transformers and adopting ensemble learning strategies could enhance accuracy and resilience in varied environmental conditions.

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