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PyTLiDAR: A Python Framework for Tree QSM Modeling from Terrestrial LiDAR Data

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Software

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Summary

PyTLiDAR is an open-source Python software package that ports the MATLAB-based TreeQSM algorithm into Python, also providing an accessible, extensible, and GUI-driven alternative for researchers and practitioners in forestry, ecology, and 3D vegetation modeling. The software reconstructs Quantitative Structure Models (QSMs) of trees from terrestrial LiDAR scans and provides interactive visualization tools for inspecting model quality and derived tree metrics.

Key features of PyTLiDAR include:

-A full reimplementation of TreeQSM's core logic in Python

-A user-friendly GUI built with PyQt6 for batch or single-file processing

-Automated and manual configuration of model generation parameters, including patch diameter ranges

-Support for interactive 3D visualization of tree models and parameter tuning

-Batch data processing

Statement of need

TreeQSM has been widely used in forestry and ecology for modeling three-dimensional tree structures from terrestrial laser scanning (TLS) point clouds. However, its reliance on MATLAB creates a barrier for users without a commercial license or familiarity with the MATLAB environment. Furthermore, the lack of a graphical interface and real-time visualization options makes parameter tuning and model validation labor-intensive and opaque.

PyTLiDAR addresses these challenges by providing a native Python implementation of TreeQSM's core algorithms, wrapped in a streamlined graphical interface that allows researchers to visualize and evaluate their models dynamically. It promotes reproducible and exploratory research by offering transparent parameter control, open-source licensing, and seamless integration into Python-based analysis workflows. This work lowers the barrier for adoption of QSM modeling by removing the MATLAB dependency, enhancing accessibility for the broader open-source geospatial and ecological modeling community.

Software Description

PyTLiDAR is implemented in Python and uses PyQt6 to create an intuitive interface for parameter configuration and data processing. Upon launching the application, users are presented with fields to input or generate values for key modeling parameters, including the initial, minimum, and maximum patch diameters. The application supports both numeric entry and automatic generation of value ranges based on user-defined counts.

Users may choose between batch processing of an entire directory of point cloud files or processing a single file. An intensity threshold can be set to filter the point cloud data, helping to remove noise and irrelevant data before modeling. The GUI also includes options for showing only the optimal model, based on selectable performance metrics such as 'all_mean_dis', and provides a dropdown menu to choose the preferred metric.

Once processing is complete, PyTLiDAR provides interactive 3D visualization of the generated QSM using plotly. Users can inspect the structural fidelity of the reconstructed model, including trunk and branch geometry, and compare different parameter configurations for best fit. This combination of visual feedback and customizable processing offers an efficient path toward accurate and transparent tree structure analysis.

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References