Doctoral School of Information and Biomedical Technologies

Polish Academy of Sciences (TIB PAN)

Subject:

Close-Range Remote Sensing for Tree Species Recognition using Ground-Based Images

Supervisor:

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Description:

Tree inventory is one of the crucial aspects of forest management. Monitoring the health and growth of trees is an important parameter to consider [1]. One step towards health monitoring is identifying individual trees and their species [2]. This task is relatively straightforward for forestry experts, yet it becomes time-consuming and labor-intensive when dealing with a large number of trees across extensive areas. In order to overcome this matter, advances in technology, particularly in the field of artificial intelligence can be used to create automatic tree species recognition [3]. Species recognition of trees can be accomplished based on several characteristic features of a tree. Geometrically, various tree species can be distinguished by the structure of their trunks, bark texture, leaf shapes, and fruit morphology. Spectral information, on the other hand, enables differentiation through the digital number or reflectance values contained within the images [3-7]. This study focuses on the utilization of close-range remote sensing, employing a method that utilizes ground-based cameras. It aims to identify tree species by analysing vertical photos taken from the ground, emphasizing three key characteristics: the shape of the tree trunk, the texture of the tree bark, and the spectral values contained within, which serve as the basis for identification.

Only a few previous studies have been concerned with this topic. In the tree species recognition process, relying on bark, as demonstrated in the research by Carpentier et al. (2018), offers many advantages compared to other attributes such as the appearance of leaves or fruits. Firstly, bark is always present regardless of seasonal changes. In the case of a standing tree inventory, the bark tends to be visually accessible to ground cameras. However, classifying tree species using only images of the bark is a challenging task that even trained humans struggle with, as some species have only very subtle differences in their bark structure [5]. Therefore, it is also necessary to consider other characteristics, such as the structure of the trunk and branches. In this case, some tree species have unique structures which can distinguish them from others [6]. Itakura et al. (2020) demonstrated structure identification using ground photos from a 360° camera, which can capture crucial tree features. However, their method was limited to single tree identification and did not extend to determining species [7]. In the previous year, Zhang et al. (2019) attempted to analyze several methods for identifying tree species based on leaf shape, and their results were quite effective. Nevertheless, it is important to note that leaves are highly seasonal, thus this method may be less suitable when applied to trees in leaf-off conditions [3].

Key tasks of the project include:

The objective of this research is to develop an automatic tree species identification system using vertical images taken from ground level. As been stated before, the focus will be on three primary characteristics: the structure of the trunk & branches, the texture of the bark, and the spectral values contained within. This study aims to leverage AI techniques to create an identification algorithm that operates at the single-tree level. It is expected that through this study, tree species identification can be done easily and rapidly to support forest management.

Methodology

1. Data Collection

- Study Area: Forests with diverse tree species.
- Image Acquisition: Use mobile phone cameras to capture vertical images of trees. Ensure that images cover the trunk structure and bark texture adequately.
- Metadata Collection: Record metadata for each image, including GPS coordinates, tree species, and environmental conditions.

2. Data Preprocessing and Annotation

- Image Preprocessing: Enhance image quality through noise reduction, contrast adjustment, and cropping to focus on the trunk and bark.
- Annotation: Manually annotate the images with the correct tree species labels. Create a balanced dataset to avoid bias in the model.

3. Feature Extraction

- Trunk Structure Features: Extract geometric features of the trunk and branches, such as trunk diameter, branch angles, and branching patterns.
- Bark Texture Features: Use texture analysis techniques to extract distinctive bark texture features.
- Spectral Features: Identify digital numbers and reflectance values at certain wavelengths, calculate spectral indices, and then derive metrics revealing important tree characteristics

4. Model Development

• Classification Algorithm: Experiment with various AI models such as Machine Learning, Deep Learning, or Convolutional Neural Networks (CNNs).

• Integration of Features: Combine trunk structure, bark texture features, and spectral features to form a comprehensive feature set for each tree.

5. Model Training and Validation

• Training: Split the dataset into training and validation sets. Use crossvalidation techniques to ensure robust training.

• Validation: Evaluate the model on the validation set and assess metrics such as accuracy, precision, recall, and F1-score.

6. Evaluation and Refinement

• Performance Evaluation: Test the model on an independent test set to evaluate its real-world performance.

• Error Analysis: Analyze misclassifications to identify areas for improvement.

• Model Refinement: Iterate on the model based on feedback from the evaluation phase. Implement techniques such as data augmentation and ensemble learning to enhance accuracy.

The expected outcome of this research is a high-accuracy AI based model capable of accurately identifying tree species based on trunk structure, bark texture, and spectral value. This automated system could be deployed in the field for real-time tree species identification, significantly aiding in efficient tree inventory and management, and supporting sustainable forestry practices.

Candidate Requirements:

1. A Master's degree (M.Sc.) in Computer Science or a relevant field.

2. Proficiency in Python programming.

3. Preferentially experience in at least one of the following areas:

- Implementation and training of neural networks.
- Profiling and refactoring code.
- A strong scientific curiosity and interest in AI.

Candidate should contact dr hab. inż. Janusz Będkowski (januszbedkowski@gmail.com) before formal submission of documents.

Bibliography:

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