



Automated Recognition of Tree Species by Laser Scanning from 3D Geometric Texture of Tree Barks: Case of the Wadi Cherrat Arboretum

Iliasse Abdennour^{1,2(✉)}, Demelele Mah³, Abdes Samed Bernoussi¹, and Mina Amharref¹

¹ GAT Team, Abdelmalek-Essaadi University, B.P. 416, Tangier, Morocco
iliasseabdennour@gmail.com

² MMC Team, Abdelmalek-Essaadi University, B.P. 416, Tangier, Morocco

³ Abdelmalek-Essaadi University, B.P. 416, Tangier, Morocco

Abstract. This work aims to develop an efficient and intelligent method for forest resource management. The objective is to implement an automatic tree species identification system based on 3D data obtained from terrestrial laser scans. The approach adopted concerns first the acquisition of 2D and 3D data, then the processing of LIDAR data and finally a process of identification of tree species by machine learning. A platform is designed and developed to meet this objective. The platform is a means that can be used by local researchers for the identification of tree species, providing a forestry database of the Wadi Cherrat arboretum.

Keywords: Species identification · LIDAR · Forest resource management · Forestry database

1 Introduction

The recognition of tree species is of great interest. This task is quite complex for people without botanical knowledge. To make this task easier to understand, it would be interesting to develop tools for species recognition and identification [1]. In most cases, the most common way to recognize a tree is to observe its leaves and/or bark: [2]. However, there are serious difficulties with this method. First, for many species, leaf or bark affiliation varies considerably over the years. A second is the effect of light exposure, some leaves may be exposed to direct sunlight, others less so (due to the density of surrounding foliage). This results in a variation in leaf color [3], leaves of the same species may have a different color. In addition, there are other important factors that complicate the problem of

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recognition, namely variability within a species and similarity between different species [4].

In this context and to overcome the recognition difficulties mentioned above, techniques other than observation have been developed. These include 2D image processing techniques, hyperspectral remote sensing and terrestrial lidar remote sensing. Regarding the image processing technique, a significant number of works have been carried out on the identification of plant species from images [2]. To recognize the species of a tree from a given image, a processing chain composed of five main steps is proposed:

1. Acquisition and pre-processing of the photo
2. Attribute extraction
3. Classification
4. Merge
5. Decision making

Furthermore, tree species recognition from images is mainly based on leaves. However, the use of leaves alone can be limited since this organ is present only during a period of the year. Buds, fruits, flowers are also very characteristic but they are not part of the tree species all year round.

Another means of tree species recognition is hyperspectral remote sensing based on the spectral signature of plants [5]. Microspectral remote sensing is the measurement of reflected radiance in narrow, contiguous spectral bands, especially the visible and infrared spectrum reflected from the sun [10]. The reflectance of a plant is mainly a result of the optical properties of its leaves. Each type of plant or tree has a unique spectral signature that depends on its growth, but also on environmental conditions and constraints such as humidity, temperature. Variations in reflectance can also be related to the optical properties of the leaves: pigment content, leaf anatomy, cell structure, or water content. This method requires aerial photographs or satellite images of high and even very high spatial and spectral resolution. This requires costly means.

In this paper, we opted for the technique of tree species recognition by laser scanning using the 3D texture of tree bark [6]. Lidar or laser remote sensing is an active remote sensing sensor in the optical domain. According to current research, the 3D geometric texture of the bark is the most suitable for tree species identification in this Lidar recognition technique [7]. This technique is based on the following steps:

1. Point cloud acquisition
2. Pre-processing
3. Processing
4. Feature extraction
5. Classification

The rest of the paper is structured as follows: we describe the methodological approach for tree species identification, including the lidar recognition technique in Sect. 2. We then present the design and structure of the platform in Sect. 3 and end with a conclusion and outlook.

2 Methodology

The objective of this work is the implementation of a platform for the intelligent management of forest resources and more specifically the identification of forest species. The platform is a means that researchers can use as a database of forest resources on given regions. The forest species identification proposed in this paper consists of five steps (Fig. 1): data acquisition, preprocessing, processing, feature extraction and classification. The last two steps (feature extraction and classification) rely on machine learning techniques. In this paper, we focused on the first three steps (data acquisition, preprocessing and processing). The development of supervised classification using machine learning will be the subject of future publications.

This section presents our approach to tree species identification from 3D terrestrial laser scanner data (Faro Focus 3D in our case), including the tools used and a description of the three stages of terrestrial lidar data.

2.1 Tools and Technologies

Faro 3D Laser Scanner: is an ultra-fast 3D laser scanner for 3D surveying of large objects, 3D digital drawings and detailed documentation. The Focus uses laser technology to generate highly detailed three-dimensional images.

Faro Scene: is a software package from the Faro company, and allows the processing of point clouds by being specialised in data consolidation. From the different surveys carried out with the scanner, we obtain different files (.fls).

3D 360° Camera: The 360° camera is capable of capturing high-resolution photos or recording 4K video and even broadcasting live in 360°.

CloudCompare: is an open source software allows the detection and visualisation of differences between point clouds. Is very efficient in processing large point clouds and for point cloud manipulation, modification and analysis.

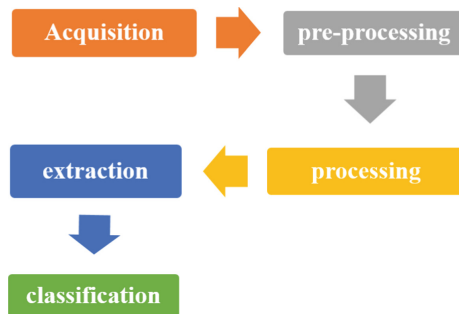


Fig. 1. Outline of the methodological approach for identification of forest species.

MeshLab: is a mesh creation and editing software offering extremely powerful tools for creating meshes and geometries from point clouds.

Computree: is a computer platform for processing 3D point clouds in the forestry context. It is managed by the Computree group.

2.2 Pre-processing and Processing of Lidar Data

LIDAR (Light Detection And Ranging) is a data acquisition technique that uses an active sensor with laser beams. With this acquisition technique, distance is mainly measured, either by measuring the round-trip propagation time of a light beam emitted by a laser or by measuring the phase shift between the beams emitted and received by the sensor [8]. Lidar allows the positions of target points to be determined and recorded in its own frame of reference, thus producing a set of points defined mainly by their coordinates. These 3D points covering the scanned surface are called a point cloud. The study and processing of these data is done by “Lidargrammetry” or “Lasergrammetry” which is a branch of Lidar [9].

2.2.1 Consolidation of the Point Cloud

The acquisition of the data requires several scanning stations. It is therefore necessary to consolidate the data in order to reconstruct the scene. For this purpose we used the faro Scene builder software which offers the possibility of semi-automatic or manual registration using two types of targets: artificial targets and natural targets.

1. Natural targets are points and objects that are part of the scanned environment (planes, angles, edges, rectangles, ...).
2. Artificial targets are either checkerboards (requiring a minimum of 4 points per quadrant to be detected) or spheres.

2.2.2 Segmentation and Extraction of Tree Trunks

This part was carried out in several steps. The first step was a manual segmentation with the CloudCompare tool. This segmentation allowed us to remove areas of no interest in the project, which will facilitate the extraction of the tree trunks (See Fig. 2a).

After this segmentation we extracted only the tree stems from the rest of the point clouds. This phase required several other manual, semi-automatic or filtering segmentation phases. After a series of extensive treatments, the tree trunks are isolated from the rest of the point cloud, as can be seen in Fig. 2b.

2.2.3 Modelling and Texturing

To ensure a good quality structured mesh model, it is necessary to perform the following steps in Meshlab as shown in Fig. 3:

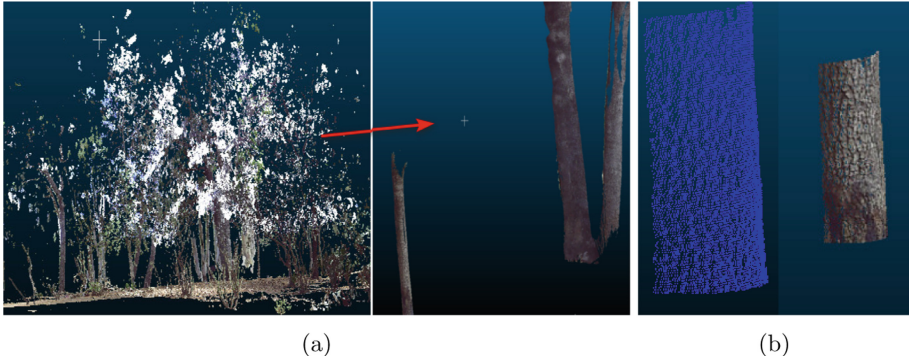


Fig. 2. (a) Tree trunks isolated from their environment; (b) Tree trunk segments.

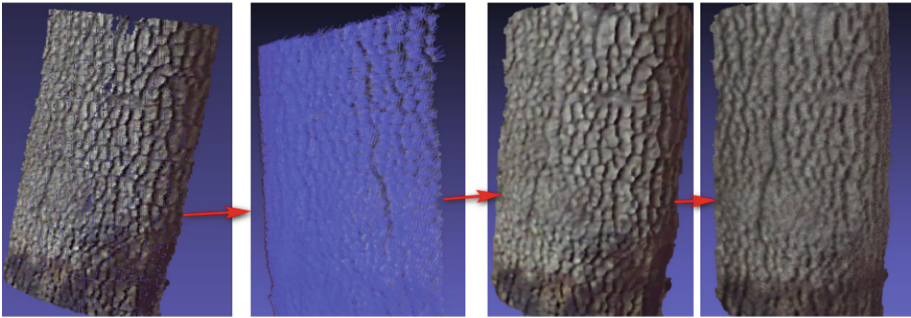


Fig. 3. Steps in creating the textured mesh.

1. Importation the point cloud to be modelled into Meshlab. To limit the loading time, it is preferable to import the cloud in (. Ply) format.
2. Calculation of the point normals by KNN (K-nearest-neighbour).
3. Meshing on the point cloud using fish reconstruction.
4. Textured the mesh using colour attributes of the point cloud.

2.3 Construction of the Image Database

In order to classify tree species, we will need hundreds of images of different species to form a good classification classifier. In our case, the data is collected during the visits we made to the arboretum of Oued Cherrat, we took several pictures of different species.

The next step of this work will be to carry out treatments that can lead to the identification of the different tree species present in the arboretum of Oued Cherrat.

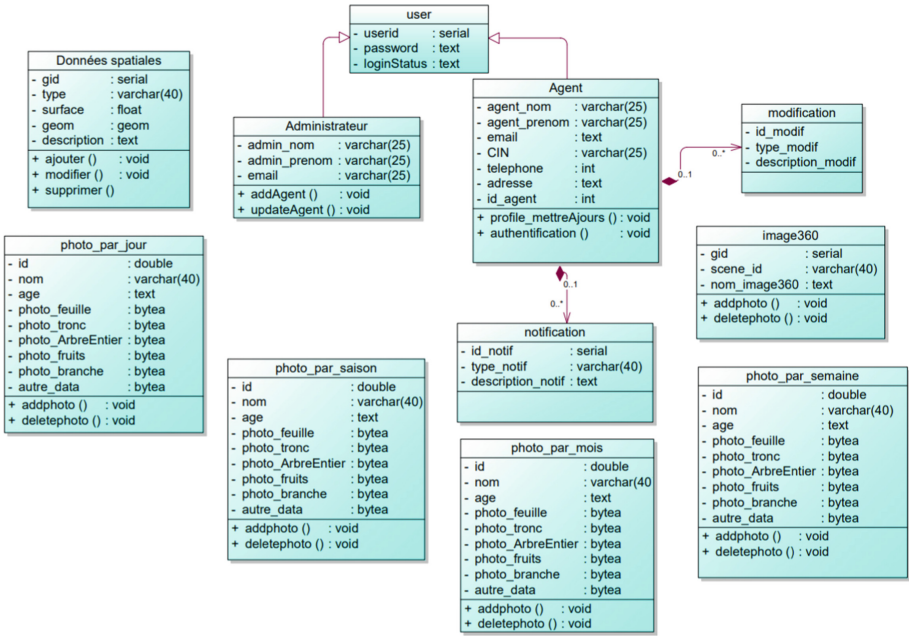


Fig. 4. 3D Web-GIS class diagram

3 Design and Implementation of the Platform

In this section, we discuss the management of data after acquisition and pre-processing for integration into the 3D Web-GIS platform. The platform is developed to monitor and make decisions on issues related to the management of forest heritage: the case of Wadi Cherrat Arboretum.

-The reforestation perimeter of wadi Cherrat created in 1932, then converted into an Arboretum since 1945, is located in the biogeographic domain of North Atlantic Morocco between latitudes 33° 48' 00" N 33° 49' 30" S and longitudes 7° 05' 30" W and 7° 07' 30" E.

3.1 Functional Architecture of the Solution

Our application is divided into three parts:

- Administrator part: allows the approval or rejection of changes made by agents, the management of agents and the management of database essences and 360° images.
- Agent part: implements the management tasks of the database essences and 360° images.
- Consultation part: visualises the information contained in the platform

The Fig. 4 illustrates the platform class diagram.



(a)



(b)

Fig. 5. (a) Home page of the platform; (b) visualization of the Wadi Cherrat point cloud.

3.2 Platform Presentation

The user of the platform is directed first to the authentication page (Fig. 5a). The tree recognition functionality on the platform provides access to the following parts:

- Identification: It should allow a user to identify the different tree species present in the Wadi Cherrat arboretum when entering the species image.
- Plant life cycle monitoring

Plant life cycle monitoring provides access to four options; Monthly, Weekly, Daily and Seasonal. The platform also gives the possibility of 3D visualization

of the Wadi Cherrat point cloud. The user can perform measurements on the point clouds such as: angle, point coordinates, distance, height, area and volume measurements (Fig. 5b).

4 Conclusion

The objective of this work was to provide a tool to facilitate the management of forest resources. Indeed, we set up a platform allowing a 3D visualisation of point clouds, images, but also a follow-up of the state of the various tree species. Nevertheless, there are still prospects for improvement, notably:

- Automated identification of tree species from their image, laser scan or spectral signature data
- Display of spatial layers
- Extension of the solution to other forests in Morocco
- The implementation of an interactive system of virtual tourism of the forest.

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