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Change – The transformative power of citizen science

UrTrees: a mobile app to involve citizens in measuring urban trees

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Abstract

Trees provide essential ecosystemic services (e.g. stocking carbon or locally regulating temperatures) and play an important role in the resilience to climate change, especially in urban areas. Quantifying these services in cities is difficult because little information is known about each tree, and no allometric model yet exists for urban trees.

The UrTrees project calls the citizen to the rescue to help collect measurements and increase our knowledge of urban tree key features. Using the mobile app that we have designed, only a short video around the tree is necessary to approximate three key measurements: the tree height, its diameter at breast height (1m30 above ground) and the crown volume. No expertise in trees is required to use UrTrees, which has even been tested on children from 6 years old.

A 3-dimensional point cloud of the scanned tree is first derived from the video using Structure-from-Motion algorithms. Geometric models for the trunk and the crown are then fitted to the point cloud in order to estimate the key measurements.

Additionally, Pl@ntNet can be used to identify tree species. All measurements are stored in a database providing data for urban tree studies and feedback to the mobile app user. Efforts have been put into the mobile app user experience, with a scoring system, daily quests and point cloud interactive visualisation. Individual tree information collected through the app will be made freely available to the general public.

Keywords: citizen science, urban tree, 3D point cloud.

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Introduction

The urban landscape that is familiar to us is mainly made up of buildings, transport infrastructure and urban furniture. However, urban vegetation, and more specifically urban trees, are also major elements of these spaces since they offer a very wide range of ecosystem services (air filtering, microclimate regulation, reduction of noise, cultural and recreational appeal, socio-economic role) (Bolund and Hunhammar 1999; Wilkerson et al. 2018). For example, they play a dominant role in carbon storage or air circulation and appear as refuge zones for urban biodiversity. Their emotional and cultural value is also not negligible for human populations.

Quantifying these services is difficult because little information is known about each tree. Indeed, urban trees being different from trees in natural environments (regular pruning, soil composition, air pollution, etc.), the classical methods of foresters to obtain allometric models (Picard et al. 2012) do not apply to them. Therefore, an exhaustive inventory of urban trees and their characteristics is essential to better identify the ecosystem services they provide, in particular in the context of climate change (Rötzer et al. 2019). However, collecting this data is costly in terms of human and logistical resources, thus limiting the spatial and temporal dimensions of the studies carried out.

Related work

Citizen science has already been used for monitoring urban trees for various purposes (Goodenough et al. 2017). However, these studies also highlighted the heterogeneity of the success of these approaches and the variable quality of the data collected by citizens (Roman et al. 2017; Vogt and Fischer 2017). It therefore seems that simplifying the data acquisition protocols (in order to avoid the need to train participants) on the one hand, and retrieving the tree characteristics by non-human means on the other hand make it possible to increase the reliability of the collected data. The UrTrees project proposes a simple video acquisition protocol and a data processing pipeline that allows any citizen without any training to measure three key urban tree characteristics with only a smartphone.

Several applications on smartphones have emerged allowing to massively collect data on trees (Trees Count; Arboreal – Tree). However, this data usually remains closed and inaccessible to the public. Other solutions have been recently proposed to recover tree measurements from a video, e.g., (Ahamed et al. 2023; Wu et al. 2023). However, they are not fully automatic as they require some manual interaction for the scaling. In addition, some key features such as the tree crown volume are not computed.

Objectives and methodology

UrTrees calls the citizens to the rescue to increase our knowledge of urban tree features. The objectives are twofold. On the one hand, we aim at a better understanding of the urban trees growth and services, by mapping and measuring urban trees in order to adapt forest allometric models to urban environments. On the other hand, our goal is also to make citizens aware of their environment and ecosystem services provided by their neighbouring trees. To do so we have developed a mobile app (running on Android) that allows citizens to record videos of urban trees, as well as a data processing pipeline that automatically computes 3D measurements of recorded trees from these videos.

The mobile app

Screenshots of the mobile app are displayed in Figure 1. The instructions to record a video of the tree are very simple: the user only needs to keep the phone at her or his eye level and go around the tree with the trunk axis always in the centre of the video. We ask her or him to film vertical lines starting from the ground. No expertise in trees is required, and this protocol has been tested with children from 6 years old. Our experiments show that going around a bit more than half of the tree is enough, even in the presence of street furniture. Efforts have been put into the mobile app user experience, with feedback given to the user and gamification elements: the app includes a scoring system, reward points, levels to reach, and daily quests. On top of the computed tree measurements, the feedback includes the 3D point cloud of the tree that the user can visualize in augmented reality. Thanks to the Pl@ntNet API (Bonnet et al. 2020), in case the user also provides a picture of a leaf, flower or the bark, the tree species is also retrieved. In addition, marking the GPS coordinates of the tree will allow in the future the user to track the evolution of the tree measurements.

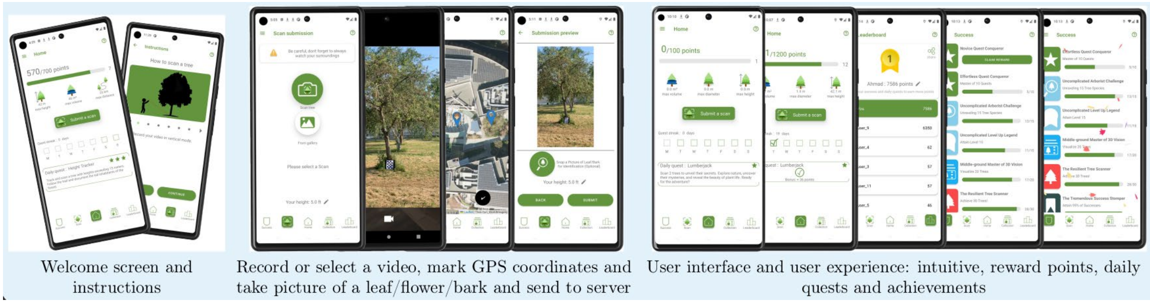

Figure 1. The UrTrees mobile app.

The data processing pipeline

A 3-dimensional point cloud of the scanned tree is derived from selected frames of the video using a Structure-from-Motion algorithm (Schonberger and Frahm 2016). Panagiotidis et al. have shown that such an approach allows to estimate tree height and trunk diameter at breast height (1m30 above ground) with accuracy similar to a LiDAR approach, even if this accuracy decreases with tree height (Panagiotidis et al. 2016). This 3D point cloud includes the target tree, but also unwanted elements for automatic measurements (noise, walls, urban furniture, neighbouring trees). It is therefore essential to segment the tree to be studied in the 3D data. We have integrated simple approaches to first remove points corresponding to vertical plane surfaces such as building walls or road signs and then isolate all the points belonging to the tree studied. It allows in particular to isolate a tree in a line from its neighbours. Finally, we compute a concave hull of the tree crown with guaranteed topology. Scaling is automatically computed using the user height and the vertical distance from the camera to the (automatically detected) ground, without any need of an additional element such as a QR code or a chessboard. We are thus able to estimate three key measurements: the tree height, its diameter at breast height and the crown volume. Others, such as the crown projected area on the ground, would also be easy to compute since we recover the tree crown, the trunk and the ground separately.

Limitations and perspectives

UrTrees is an ongoing work. As such, the measurements accuracy and robustness to various parameters have not yet been fully evaluated. Our initial tests show that the scaling error is less than 5% of the tree height. Individual tree information and measurements collected through the app are stored in a database and will be made freely available to the general public. Following the Principles of Citizen Science, we plan to make all UrTrees data Findable, Accessible, Interoperable and Reusable. We expect this data to allow to develop allometric models for urban trees. We would like to develop and interact with some user communities, for example in a local area or for a specific purpose such as green space management. Hopefully, their feedback can help us improve the project and go from simple data collection and "Distributed Intelligence" to "Participatory Science" (Sui et al. 2012).

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