Survey of urban greenery using point cloud data

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1. Introduction

Urban greenery is an important component of the city that brings a variety of benefits to the formation of a good urban environment, but it is difficult to grasp its current status. Therefore, the Urban Planning Department is working on a study of the methods for quantitative evaluation of the effect of greening to improve the urban environment.

The purpose of this study is to develop advanced methods for surveying the current status of greenery throughout the city, including privately owned land, using the latest measurement equipment and AI, as well as to develop technology for quantitative analyses of the benefits of greenery, to make the results of greening efforts visible and assessable, and to provide technical support for the greening policies of local governments.

This paper introduces the results of examining a three-dimensional survey method of urban greenery using point cloud data in consideration of its use in numerical simulations.

2. Three-dimensional measurement of greenery

The effects of greenery on the urban environment are diverse and wide-ranging. Yet, this study focuses on the multifaceted functions of greenery, particularly the effects related to physical phenomena, such as mitigation of the heat island effect and prevention of the spread of fire, as well as visual psychological effects, such as landscape enhancement.

In order to evaluate the effectiveness of the greenery present in the city, in addition to confirmation by actual measurement data, it is effective to model the physical phenomena and conduct numerical simulations to quantitatively analyze the effects.

To examine the effect of greenery in numerical simulations, it is necessary to model and incorporate the effect of greenery in the basic equation and to input its shape as a 3D model, as well as other components, such as buildings. Various numerical simulation models that take into account the impact of greenery have already been developed, but there is still no established method for obtaining current greenery data for use in such simulations.

The green coverage ratio, which is used as an indicator to grasp the total amount of greenery in a city, captures the amount of greenery in terms of the flat area of green coverage, so both lawns and trees are treated the same. This means that it is not possible to reflect the effects related to height, such as the shade effect of trees. By adding the height information of trees to this green coverage, it becomes possible to understand the three-dimensional distribution of greenery.

3. Acquisition of point cloud data targeting greenery

Point cloud data is already being used in various situations, such as i-construction and automated driving. The devices and technologies for acquiring point cloud data are becoming more widespread. Recently, LiDAR (light detection and ranging) has been installed in smartphones (Figure 1) and tablet devices, making point cloud data more accessible.

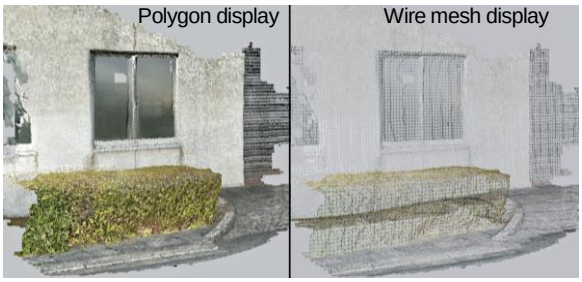

Figure 1: 3D data measured using a smartphone

① Measurement by aerial laser

The wavelength of the laser used in commonly available aerial lasers is in the near-infrared range, a wavelength that is highly reflective by plants. On the other hand, the Airborne LiDAR Bathymetry (ALB) for underwater depth measurement uses lasers with green wavelengths in addition to near-infrared light. It is possible, to a certain extent, to use this on land and classify plants and buildings by using the difference in reflection intensity depending on the wavelength. [1] (Figure 2)

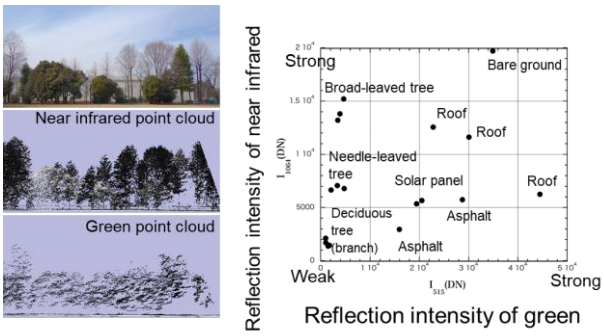

Figure 2: Difference of reflection intensity against laser wavelength

② Measurement by laser on board of vehicle

LiDAR mounted on a Mobile Mapping System (MMS) used for road surveys etc. can capture the condition of street trees and other plantings along the road (Figure 3).

Since the laser beam is emitted from the side, the conditions under the tree canopy can be captured, which is difficult to grasp with an aerial laser from above.

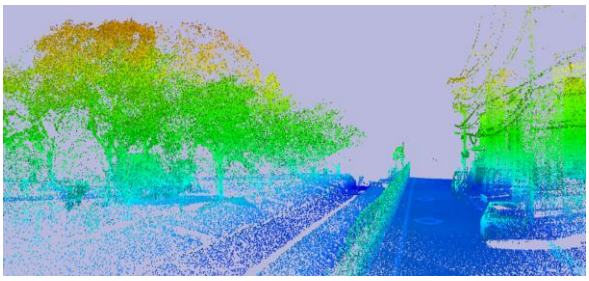

Figure 3: Point cloud data captured through MMS

In-vehicle lasers are already being used for the automatic braking of some vehicles, but they are expected to become an emerging technology for more advanced automated driving. The data developed by Simultaneous Localization and Mapping (SLAM) has the potential to be used for various purposes in the field of urban studies as city shape data that can be updated as needed.

③ Measurement through photogrammetry

There has been great technological advances in the methods of acquiring point cloud data, not only by laser measurement but also by photogrammetry. For example, Structure from Motion (SfM) is one of the technologies to create point cloud data from multiple photos, including GPS and other location information. This makes it possible to create point cloud data (Figure 4) from images captured by a camera mounted on a drone or a handheld compact camera. While it is difficult to survey an entire city with drones or through ground-based surveys, it is possible to survey a limited area, such as a park, at a reduced cost.

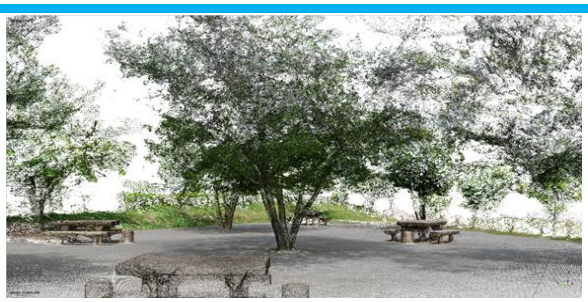

Figure 4: Point cloud data created from photos taken by digital cameras

4. Producing 3D model for simulation

The greenery surveyed by the point cloud data is represented as a 3D model (in this case, DCHM: Digital Canopy Height Model is used) for numerical simulation (Figure 5).

Figure 5: DCHM data (the darkness of the green color representing tree heights)

When representing the shape of a tree or other object in a simulation, the range of the tree canopy is shown on the computational mesh because the shape of leaves and branches cannot be reproduced in detail as polygons. As a specific example, in fluid flow calculations, tree parameters, such as resistance coefficients, obtained from wind tunnel experiments are set on the mesh where trees exist. Another method that is under consideration is to give the leaf area density, which indicates the condition of leaves in the mesh, by estimating it from point cloud density and other data.

5. Conclusion

Currently, 3D city models are being developed for urban DX (digital transformation), focusing on building data, but it is expected that tree data will also be developed in the same way as building data in the future in order to make it possible to study the urban environment, including the effects of trees.

☞For more information:

1) Masamiki Ohashi, “A Study on Vegetation Survey by Aerial Laser Profiler,” Lecture Compilation DVD-ROM of the 2018 Architectural Institute of Japan Assembly, pp. 871-872.