RECENT RESEARCH ACTIVITIES

Computer vision-based wood anatomy

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Training a sufficient number of frontline workers to perform wood identification has always been a big challenge in the wood industry. In recent years, the remarkable advancement in the field of artificial intelligence (AI) has created a new research field in wood science called computer vision (CV)-based wood identification. Since most of the CV-based wood identification studies focused only on the development of automated wood identification systems, understanding of the wood itself was neglected, and consequently their achievements were difficult to extend to various subfields encompassed by wood science. For the further expansion of AI technologies into wood science in this context, we aim to understand CV based on the domain knowledge of wood anatomy.

Local features, which are distinct structural elements such as points, corners, and edges in an image, are suitable for approaching the microscopic scale image used in established wood anatomy. From clustering analysis of local features detected in cross-sectional micrographs of wood, it was confirmed that the features can be classified into major anatomical elements of interest in conventional wood anatomy [1]. In addition, it has been found that local features encoded by clustering can be used as anatomical predictors for quantitative wood anatomy, as well as improving discriminative power for wood identification [2]. Combining this method with an image partitioning strategy, especially radial partitioning from pith to bark helps to distinguish wood porosity. Feature importance measures based on the rarity of image features detected by CV provides clues to predict species-specific features. In Fig. 1, both species in Lauraceae have vessels as informative features, but in more detail, the species-specific features are large earlywood vessels for *Sassafras tzumu*, whereas inter-vessel pitted walls for *Lindera communis*. As such, anatomical approaches to CV may provide clues and new insights into species-specific morphology that have not yet been identified in established wood anatomy.

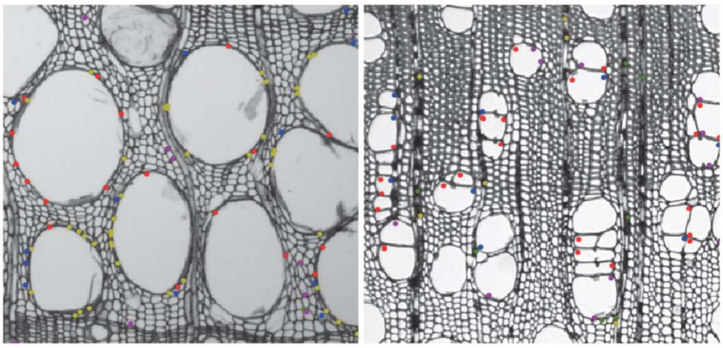

Figure 1. Species-specific features of *Sassafras tzumu* (left – large vessels in earlywood) and *Lindera communis* (right – inter-vessel pitted walls) determined by computer vision.

As a digitized database of the wood collection of the Kyoto University Xylarium database, the recently released Xylarium Digital Database (XDD) for wood information science and education covers the widest biodiversity among the open wood digital databases currently available. Based on the anatomical studies mentioned above, XDD was built with two pixel resolutions and consists of a total of 16 micrograph datasets (https://repository.kulib.kyoto-u.ac.jp/dspace/handle/2433/250016?locale=en). In the historical context where there was no large wood database annotated by wood experts, the emergence of XDD could make an important contribution to the advancement of wood science with deep learning techniques as well as conventional machine learning.

References

[1] Hwang S. W., K. Kobayashi, S. Zhai, J. Sugiyama, "Automated identification of Lauraceae by scale-invariant feature transform", *J Wood Sci*., vol. 64, no. 2, pp. 69-77, 2018.

[2] Hwang, S. W., K. Kobayashi, and J. Sugiyama, "Detection and visualization of encoded local features as anatomical predictors in cross-sectional images of Lauraceae, *J Wood Sci*, vol. 66, no. 16, 2020.