Rapid Health Assessment of Trees via Deep Learning-Augmented Radar

Jiwei Qian(1), Yee Hui Lee (1), Qiqi Dai (1), Kaixuan Cheng(1), Liansheng He(2), Daryl Lee(2), and Abdulkadir C. Yucel(1)

(1) The School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore, 639798. (qian0069@e.ntu.edu.sg, {eyhlee, qiqi.dai}@ntu.edu.sg, chen1519@e.ntu.edu.sg, acyucel@ntu.edu.sg)

(2) National Parks Board, Singapore, 259569. ({he_lian_sheng, daryl_lee}@nparks.gov.sg)

Fast, accurate and reliable detection of tree structural defects is an important task for arborists to allow timely diagnosis and treatment of structurally unhealthy trees and consecutively avoid tree failures. Several techniques, especially various tomography techniques leveraging on ultrasound, electrical resistivity, and microwave technologies have been employed for this task. Such techniques require time-consuming measurement campaigns, long processing times to obtain the images, and deployment of multiple transmitters/receivers, limiting their daily applications on the field. The ground-penetrating radar techniques have recently received significant attention for imaging the tree trunks and detecting tree defects (I. Giannakis, F. Tosti, L. Lantini, and A. M. Alani, "Health Monitoring of Tree Trunks Using Ground Penetarting Radar," *IEEE Trans. Geosci. Remote Sens.*, 57(7), 4417-4426, 2019). Although radar also requires considerable time for the measurement campaigns, it offers relatively short processing times to obtain images and requires the deployment of only a single transmitter/receiver. Currently, radar measurement campaigns are conducted on a circular scanning trajectory around the tree trunks. The tree defects (cavities and decays) are determined from the cross-sectional images of the tree trunks constructed using the signal processing algorithms applied to the measurement data. That said, this process is highly laborious and time-consuming, hindering the applicability of the radar to the massive health screening of trees in large forests.

In this study, a deep learning-based approach is proposed to assess the health conditions of trees via tree radar. In particular, radar measurements are conducted on a straight trajectory centimeters away from the tree trunk surface without touching the trunk. For each tree, the radar measurements that are stacked into a B-scan are processed by a convolutional neural network (CNN) to classify the trees in terms of the likelihood of the presence of significant internal defects like decay or cavities. The proposed approach is expected to be rapid and thus allow efficient health screening of trees in large urban forests as, (i) the radar measurements can be performed quicker on straight rather than previous circumferencial trajectories and (ii) the trained CNN algorithm can perform the significant defect likelihood classification instantaneously. The CNN algorithm is first trained using synthetic B-scans generated for the realistic 3-D tree trunk models with random shapes and layers with/without defects, which are processed with traditional signal processing techniques. Then transfer learning is applied to train the CNN algorithm with the measurement data. The preliminary results show that the proposed approach can accurately and efficiently detect significant internal defects like decay and cavities within tree trunks. The testing accuracy of the CNN trained with synthetic data was found to be more than 96%, which verifies the robustness of the proposed algorithm in the health monitoring of tree trunks. In the talk, the architecture of the CNN will be provided and the performance of the CNN algorithm with the measurement data will be discussed. It should be noted that a similar approach was applied to the synthetic data generated by 2-D homogeneous tree trunk models in our previous study (Q. Dai, B. Wen, Y. H. Lee, A. C. Yucel, G. Ow, and M. L. M. Yusof, "A Deep Learning-Based Methodology for Rapidly Detecting the defects inside Tree Trunks via GPR", *2020 IEEE USNC-CNC-URSI North American Radio Science Meeting (Joint with AP-S Symposium)*, 139-140, 2020). This idea is extended for the synthetic data generated for the 3-D realistic tree trunk models and the real measurement data processed using signal processing techniques in this study.