NEWS RELEASE

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NTU Singapore scientists are developing an AI-powered radar innovation that detects tree trunk defects in minutes

Scientists at **Nanyang Technological University, Singapore (NTU Singapore)** are developing a new artificial intelligence-enabled innovation that can detect cavities and decay inside tree trunks.

This effort is being led by a team from NTU Singapore's **School of Electrical and Electronic Engineering (EEE)**, with support from National Parks Board (NParks). As part of this ongoing project, a prototype has been built in NTU's labs and undergone some preliminary field testing, and is currently being finetuned.

The prototype comprises a radar that scans the trunk's interior using microwaves. Advanced signal processing techniques 'clean up' the data captured by the radar, before a deep learning model analyses the data and pinpoints any defects in the trunk. This process takes three to four minutes, from scanning to analysis and detection.

When tested on freshly cut trunks of the Angsana tree – a common roadside tree in Singapore – the scientists found that their prototype showed a 96 per cent accuracy in identifying defects within trunk samples.

These findings were reported in a research paper published in *Transactions on Geoscience & Remote Sensing*, a journal by the Institute of Electrical and Electronics Engineers.

As trees grow older and larger, they are more likely to develop defects such as cavities and decay, threatening their structural health and may lead to tree failures – the structural deterioration or breakage of any part of a tree.

In Singapore, the government implements a comprehensive tree management programme that has reduced the rate of tree failure by 65 per cent[1].

[1] *Written answer by Ministry of National Development on tree failure incident reports received by NParks, Ministry of National Development Singapore, 10 Jan 2024*

NTU EEE Assistant Professor Abdulkadir C. Yucel, who is leading this research project, said: “While Singapore has a robust and comprehensive tree management programme in place, some of the techniques to uncover the internal conditions of trees are time-consuming and labour-intensive. Our research is novel for its contactless nature among existing non-destructive methods of detecting tree internal defects. The quick and easy detection process, which is enabled by AI, has the potential to strengthen our urban tree management programme.”

NTU EEE Professor Lee Yee Hui, who is co-supervising the research project, added: “While our radar technology is unique, its use is limited to tree trunks of certain shapes and sizes. Studies are ongoing to overcome these limitations so that we can one day apply the technology to a wider variety of tree species, making it more feasible for deployment.”

Dr Shawn Lum, a tropical rainforest ecologist at NTU who is not a co-author of the study but helped the team during the development of the radar prototype with his expertise in trees, said: “Singapore has done a remarkable job of reducing the rate of tree failure dramatically with enhanced tree inspection techniques, increased frequency of checks, and rigorous tree management regimes, but risk nonetheless remains. A low probability of treefall, however low, still means that dozens of trees will fail each year, each episode a risk to people or property.”

“By combining novel applications of microwave radar technology and deep-learning algorithms, the NTU research team hopes that when the technology is operationally-ready, trees with internal defects can be flagged even earlier than permitted by current best practices, and before the risk of actual failure occurs. Reducing tree failure to zero is not possible given how even healthy trees can be damaged by a perfect storm of weather events. However, the potential risk reduction offered by this work means reduced damage to property, disruptions to transport and other vital systems, and perhaps most poignantly, personal suffering,” added Dr Lum, a senior lecturer at NTU’s Asian School of the Environment.

Other members of the NTU research team include **Research Associate Jiwei Qian**, and **PhD student Kaixuan Cheng**. NParks contributes to the ongoing research with its expertise and provides tree trunk samples to aid in the enhancement of the radar prototype.

This research is supported by the National Research Foundation, Singapore, and Ministry of National Development, Singapore under its Cities of Tomorrow R&D Programme.

How it works

Sonic and electrical resistivity tomography are currently used by arborists to detect internal defects of tree trunks. While these methods can produce cross-sectional representation of the internal tree structure to show the type and extent of defects, they are labour-intensive and time-consuming. Another technique, microwave tomography, is complex and unsuitable for quick assessments.

Researchers have also looked into a technique called ground-penetrating radar, which is simpler and faster but requires the radar to be in direct contact with the tree trunk and moved around its circumference. The unevenness of the tree bark makes this process challenging, and there are also data accuracy and processing issues.

The AI-enabled innovation developed by the NTU scientists involves a radar with novel hardware and software mounted on a motorised slider and set up 10cm away from the tree trunk. The NTU team built the motorised slider that moves the radar along a 1m straight-line path. At every 2cm mark, the radar scans the tree trunk via a novel antenna also developed by NTU scientists. A sensor in the radar ensures that the antenna always faces the centre of the tree trunk.

The scans captured by the radar contain unwanted data that must be removed so that the ‘defect signatures’ – patterns that indicate defects in the tree trunk – can be more accurately detected. To do this, the NTU team devised a three-step signal processing technique to enhance the data quality.

Finally, a deep learning model trained and tested with scans of 20 freshly cut Angsana tree trunks is used to analyse the processed data.

Field test

Having tested their AI-enabled innovation in the lab setting with cut tree trunk samples and achieving a 96 per cent accuracy in identifying samples with defects, the NTU team next ventured outdoors to conduct tests on a living hoop pine tree with a known cavity.

The team took four different scans of the tree, each time with the radar facing a different side of the tree. Their system showed a 75 per cent accuracy this time – their deep learning model identified the presence of a cavity three out of four times.

The scientists said this decreased accuracy is expected because their deep learning model has been chiefly trained on data from cut tree trunks rather than living trees due to the difficulties of finding trees with known internal defects. The data set also may not fully represent the wide variety of tree shapes and internal defects. As a result, the evaluated accuracy may not reflect the true potential of the deep learning model.

Another factor is the moisture content variation between the tree trunk samples and living trees, which could also have affected the penetration of the signal transmitted from the radar, thus lowering the accuracy.

The NTU team is now conducting more field and lab work to finetune the radar's capabilities by training their deep learning model on more living tree data and trunk samples.

The team is also working on the portability of the system and extending its application to trees with larger and more irregular trunks, allowing for different heights of tree trunks to be scanned simultaneously, so that their innovation can one day be deployed in the field for detection of internal tree defects.

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Notes to Editor:

The paper titled '*A Deep Learning-Augmented Stand-Off Radar Scheme for Rapidly Detecting Tree Defects*' is published on 11 June in *IEEE Transactions On Geoscience And Remote Sensing*, Vol. 62, 2024. DOI: 10.1109/TGRS.2024.3412286

Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not reflect the views of National Research Foundation, Singapore and Ministry of National Development, Singapore.

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About Nanyang Technological University, Singapore

A research-intensive public university, Nanyang Technological University, Singapore (NTU Singapore) has 33,000 undergraduate and postgraduate students in the Engineering, Business, Science, Medicine, Humanities, Arts, & Social Sciences, and Graduate colleges.

NTU is also home to world-renowned autonomous institutes – the National Institute of Education, S Rajaratnam School of International Studies and Singapore Centre for

Environmental Life Sciences Engineering – and various leading research centres such as the Earth Observatory of Singapore, Nanyang Environment & Water Research Institute and Energy Research Institute @ NTU (ERI@N).

Under the NTU Smart Campus vision, the University harnesses the power of digital technology and tech-enabled solutions to support better learning and living experiences, the discovery of new knowledge, and the sustainability of resources.

Ranked amongst the world's top universities, the University's main campus is also frequently listed among the world's most beautiful. Known for its sustainability, NTU has achieved 100% Green Mark Platinum certification for all its eligible building projects. Apart from its main campus, NTU also has a medical campus in Novena, Singapore's healthcare district.

For more information, visit www.ntu.edu.sg