Micro-acoustics for condition monitoring of trees

Dr. Frank Schubert, Dr. Frank Duckhorn, Dipl.-Ing. Mario Kühmstedt, Dipl.-Ing. Paul Meyer, M.Sc. Michael Reinhold, M.Sc. Martin Barth, Prof. Constanze Tschöpe, Prof. Henning Heuer

Assessing the vitality of trees is of interest in nature conservation, tree care, fruit growing and forestry. However, it can generally only be implemented with a high level of personnel and technical effort and is therefore unsuitable for continuous monitoring. It is known from various studies that in standing trees micro-acoustic sound emissions (SE) occur in the audible and ultrasonic frequency range. They allow conclusions to be drawn about the traffic safety of the tree, about drought stress and sap flow anomalies as well as possible diseases or pest infestation by beetles and mice (Tab. 1).

Tab. 1: Micro-acoustic event types with applications

Event type	Indication of	Application
Fiber cracking	Branch breakage	Traffic safety
Capillary collapse	Drought stress	Forestry, fruit grow.
Noise signal	Sap flow anomaly	Forestry, fruit grow.
Feeding sound	Pest infestation	Forestry, fruit grow.

In the current TreeMon project, funded by the BMBF (funding code: 02WDG1698B), an autonomous measurement system for micro-acoustic sound emissions is to be developed and put into practice. For this purpose, a demonstrator of a wireless SE sensor node is assembled, which is then attached to the trunk of a tree, where it records sound emissions over a longer period of time and evaluates them based on machine learning.

The digital measuring system should

- detect and classify damage and diseases that affect traffic safety at an early stage,
- suggest timely measures that prevent the trees from dying or being damaged and allow for more stable and better yields in fruit growing,
- check the effectiveness of long-term measures in forestry (e.g. cultivation of mixed forests or non-endemic tree species).

As part of first test measurements in the field, SE data was recorded and evaluated on various fruit trees, birch, fir and pine trees as well as beech and linden trees. Using piezo-based sensors and highly sensitive contact microphones (Fig. 1), it was possible to detect high-frequency fiber cracks as precursors to macroscopic branch and trunk breakage, drought stress and drying events as well as active bark beetle infestations (Fig. 2). Acoustic sap flow measurements are currently being implemented.

Fig. 1: Fruit tree instrumented with a contact microphone.

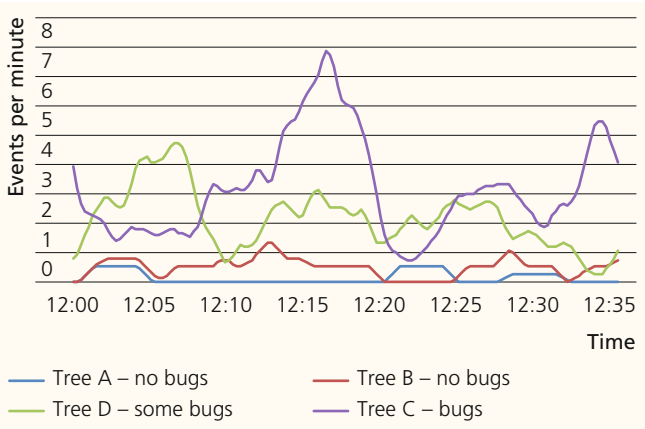

Fig. 2: Time-dependent feeding sounds of bark beetles on different pine trees.

Based on the frequency characteristics of the different micro-acoustic event types, the plan is to develop specific sensor nodes. These will be validated and optimized in a final, one-year-long field test campaign. A subsequent comparison of the acoustic data with tree vitality assessments recorded conventionally by human tree experts and drone-based multispectral cameras will lay the foundation for evaluation with machine learning methods. Similar acoustic monitoring solutions for other applications are also under development at IKTS.

Supported by:
Digital GreenTech
FONA Forschung für Nachhaltigkeit
Federal Ministry of Education and Research

Contact Frank Schubert • Phone +49 351-88815-523 • frank.schubert@ikts.fraunhofer.de