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POSSIBILITIES OF INSTRUMENTAL MEASUREMENT RELATED TO THE TREE HEALTH

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Abstract: *The stability of urban trees is a key factor that affects everyone. Sick and unstable urban trees pose a great risk to anyone. Three instruments capable of determining and evaluating the health and stability of trees are presented. One of the measuring instruments called ArborSonic FAKOPP 3D acoustic tomography, which is able to detect the size and location of decayed or hollow regions in the trunk non-destructively. Measurement working fast it can be completed in 5-10 minutes and creates a 3D model of the trunk with multiple layers of measurement. Customizable wind load modeling is included in the software. Another instruments called ArborElectro Impedance Tomogtaph. It works based on electric resistivity measurements, thus fungi attacks even in very early stages may be determined. Not every measuring device focuse on the visible parts of trees. A special measuring device capable of examining underground areas (roots) will be presented. It called Dyna Tree Root and Trunk Testing System. With the help of instrumental measurements, the health status of trees can be determined, which is a very important factor in the urban environment. In recent years we have encountered many accidents caused by the fall of rotten trees in bad health status, for example in car parks, playgrounds and parks. In addition to these, it is important to be able to decide on construction sites which tree to cut down, as it is in poor health (decayed and with hollow parts) and which is better to keep, which are healthier specimens. This helps to preserve the tree diversity of urban areas.*

Keywords: *health of trees, ArborSonic FAKOPP 3D acoustic tomography, ArborElectro Impedance Tomograph, DynaRoot Root Testing System, instrumental measurement.*

INTRODUCTION

Monitoring less healthy trees are very important, especially in urban environments. As there are fewer trees in cities, they should be prevented from being cut down unnecessarily. Sick and unstable urban trees pose a great risk to anyone. Three instruments capable of determining and evaluating the health and stability of trees are presented. The first instrument is ArborSonic 3D is a minimally invasive evaluation tool for trees. It works based on sound velocity measurements between several sensors around the trunk. s a non-destructive acoustic tomograph that can determine the size and location of decayed or hollow parts of the trunk and calculate the ratio of whole trunk and healthy wood [1]. Because sound velocity drops in decayed areas, internal holes can be detected and the stability of the tree can be estimated [2]. Examined the health of trees on 200-year-old *Quercus rubra* specimens using a Fakopp instrument and visual inspection. After felling the trees, it was confirmed that both methods were capable of identifying health problems, but the instrument was able to determine the extent and location of the deterioration with Fakopp examined sessile oak stands of different age groups, of which the 80-year-old proved to be the healthiest, while the 20-year-old showed the

worst values by [3].
The next instrument called ArboElectro impedance Tomogtaph. It works based on electric resistivity measurements. Fungi attack even in very early stages may be determined. Not only should the trees be focused on visible parts. A measuring device capable of examining underground areas (roots) will be presented. It called Dyna Tree Root and Trunk Testing System.
With the help of instrumental measurements, the health status of trees can be determined, which is a very important factor in the urban environment. In recent years, many accidents have been caused by fallen trees which were in bad health condition. With the measuring instruments mentioned above, we can find out which trees are worth (and safe to keep) and which trees that are need to be cut down due to their poor health and plant new healthy trees in their place.

MATERIALS AND METHODS

The steps for measuring the ArborSonic 3D are as follows. Drive the transducers through the bark using a rubber hammer with even spacing around the trunk. Measure the distances between the transducers with a caliper and enter the measured data to the computer. Tap each transducer with a steel hammer to generate sound waves. ArborSonic 3D measures the travel times with microsecond precision to each transducer and transmits the data to the computer. The software calculates and displays the internal sound-velocity distribution of the tree. The Measured time is precision± 2 microseconds. Sensor low noise is SD02 piezo sensor. Number of sensors variable from 8 up to 32 pieces. The instrumental'sPower consumption 240 mW and Power supplyStandard (rechargeable) 9V block battery. Continuous operation time with one battery is approximately 2 hours. Total weight is approximately 6 kg (without PC, including case, hammers and 10 sensors). PC connection RS232 over cable or Bluetooth. Data transmission time per sensor tapBelow one sec. Total measurement time of one tree 20 minutes one section, including assembly, geometry registration, tapping and disassembly, using 10 sensors. Operating temperature range 0-40°C [http 1]

The next measuring tool called Arbor Electro Impedance Tomography. First step to use the instrumental, place the resistivity meter onto the tree.
Measure the circumference and decide the proper shape (circular, elliptic or irregular). Place the electrodes onto the tree at the proper positions or measure their positions. Enter the data to the computer. Start the measurement on the computer. During the measurement do not touch the tree. Do not measure other conditions parallel to the resistivity measurement. Choose triangulation parameters and run the iterations. The program will calculate the resistivity map of the selected cross section. Excitation voltage is 5-50V and adjustable in 5V steps. The Current measurement range is 0-20mA; 0-400μA; 0-40μA. The length of one basic measurement is 640ms. Power supply built in 5V/5000mAh Li-ion Power Bank. Continuous operation time on average diameter trees Approximately 2 hours. Total weight without PC, including case and hammers approximately is 6 kg. PC connection LEMO-USB is cable or Bluetooth. Total measurement time of one tree one section, including assembly, geometry registration, measurement 45 minutes. Operating temperature is ranged betveen 0 and 40 °C [http 2].

Often tree problems that are visible in the leafy crowns of trees are caused by problems below ground in the tree's root zone. Curing these problems may be as simple as surgically removing a root that is strangling other roots, or may require complex therapy such as aerating the soil, loosening the soil, or adding special fungi to the roots to increase their absorption of water and nutrients [http 3].

The third measuring tool called Dyna Root Root Testing System.
The DynaRoot system should be used on days with at least 25 km/h (15 mph) wind gust velocities. Setting up the measurement involves the following steps. Assemble the anemometer tower in the vicinity of the tree(s) to be assessed. Attach the anemometer on the top, and erect the tower.
Wind velocity readings are sent to, and data is collected at the instrument box located at the bottom of the tower. Start recording data by pressing the start button located in the instrument box. Mount the inclinometer on the root collar of the tree to be assessed. Start recording data by pressing the start button located on the side of the instrument box. Repeat the previous 2 steps if you have more inclinometers and want to assess multiple trees. Record data are for at least 3 hours. After the recordings are finished, transfer the acquired data to a PC by removing the internal SD card or by switching the instruments to Wi-Fi mode. Load the data

into the DynaRoot evaluation software and calculate the safety factor. Useful data are from the anemometer. Sampling rate is 1 Hz. The Measurement range 0-150 km/h. Accuracy 0.2 km/h. Maximal SD card size 8GB and the anemometer instrumental is Wheatherproof (IP65). Dual axis inclinometer Measurement range ±2° and the resolution 0.001°. The Sampling rate is 10 Hz. Maximal SD card size is 8GB. Operating voltage and currents is 12 V, 20 mA [http 4].

RESULTS AND DISCUSSION

The ArborSonic 3D is a minimally invasive evaluation tool for trees. It works based on sound velocity measurements between several sensors around the trunk. Because sound velocity drops in decayed areas, internal holes can be detected and the stability of the tree can be estimated. Measurements taken at various heights can be assembled into a 3D model. Through three-dimensional measurements we can see the inside of the trees.
Green indicates a completely healthy tree, red indicates rotten trees, and blue indicates hollow areas (Figure 1).

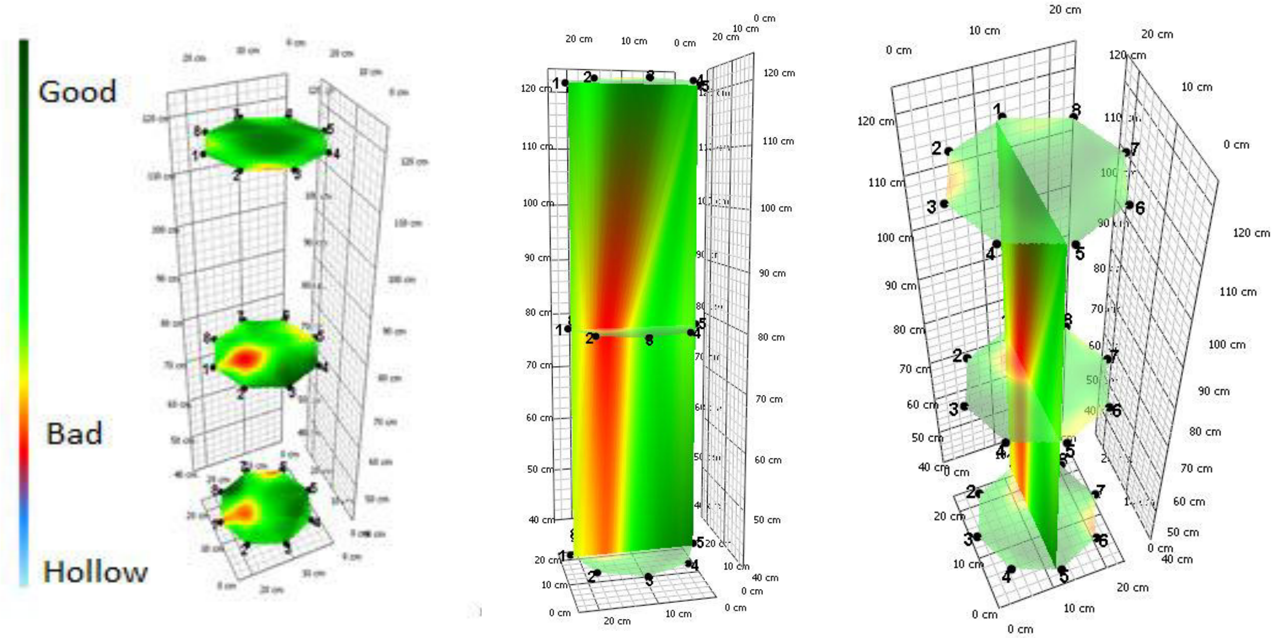

Figure (1) The figure shows a 3 dimensional image of a tree.
Three measurements were made on it, thus showing three cross-sectional images.

The next instrument called ArboElectro impedance Tomogtaph. It works based on electric resistivity measurements. Fungi attack even in very early stages may be determined (Figures 2 & 4).

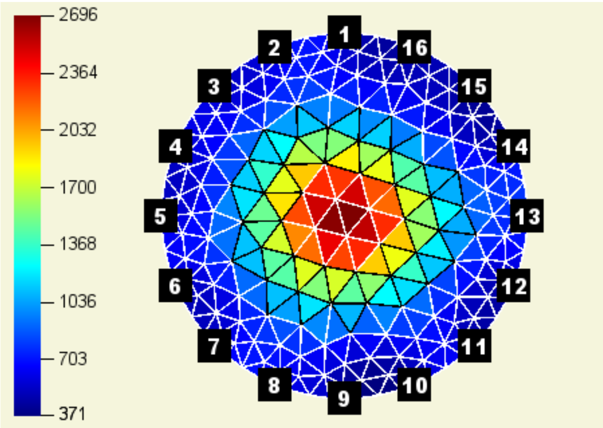

Figure (2) We can see a cross-sectional view of a completely healthy, fungus-free tree.

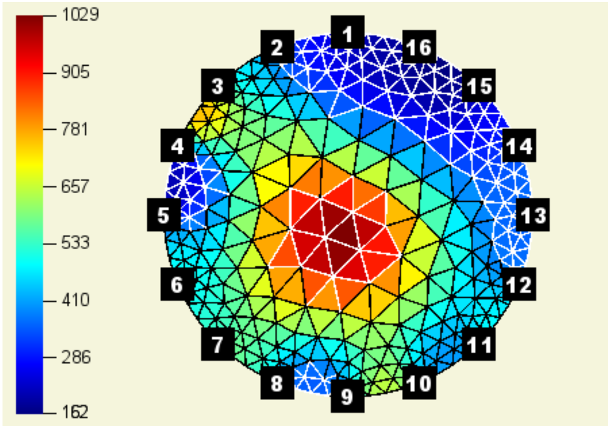

Figure (3) Here is a cross-sectional view of a tree under attack by fungus.

Not only should the trees be focused on visible parts. A measuring device capable of examining underground areas will be presented. It called Dyna Tree Root and Trunk Testing System. Examining the roots is very important, so it is worthwhile for diseased trees to examine their roots. An instrument for measuring the wind velocity is at or near the tree to be evaluated. The closer to the better, but, depending on wind velocity DynaRoot may provide reliable data even with measurements taken several kilometres/miles away. The anemometer provides wind velocity data of sufficient frequency; ideally the anemometer should be clear of buildings or other objects that may obstruct the wind, at a height of at least 10m. Dual axis inclinometer (Figure 4). An instrument affixed to the root collar that measures the inclination of the trunk in two perpendicular directions. The instrument provides very accurate inclination data with sufficient frequency.

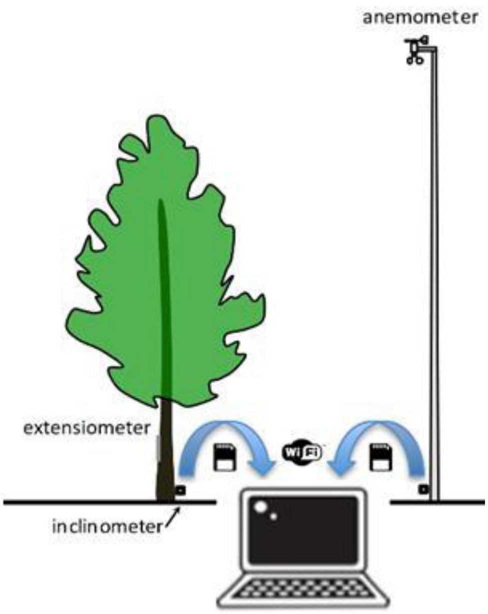

Figure (4): A PC software for evaluating wind velocity and inclination.

The data, recorded over a period of several hours, are transferred from the anemometer and inclinometer on memory cards or wirelessly via Wi-Fi. The software breaks the data down into shorter intervals, and calculates statistical parameters for each interval that are used for the tree stability evaluation (source: http4).

CONCLUSIONS AND RECOMMENDATIONS

Using these tools, the health status of trees can be monitored.
Thanks to the monitoring, we will be aware of the health status of the trees in the given area. These instruments are very useful in the long run. If we detect a disease in a tree in time, we can still treat it. By treating certain diseased trees in a timely manner, we can save them from decay and fungal attacks. This helps to preserve the diversity of the areas!

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