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Microwave sensing of tree trunks

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The main subject of this research is the observation of the inner part of living tree trunks using ground-penetrating radar (GPR). Trees are everyday part of human life and therefore it is important to pay attention to the tree conditions. The most obvious consequence of the poor tree condition is dead or injury caused by falling tree.

The trunk internal structure is divided into three main parts: heartwood, sapwood and bark, which make this medium highly anisotropic and heterogeneous. Furthermore, the properties of the wood are not only specie-dependent but also depend on genetic and on environmental conditions. In urban areas the main problem for the stability of the trees relies in the apparition of decays provoked by fungi, insect or birds. This results in cavities or decreasing of the support capacity of the tree.

GPR has proved itself to be a very powerful electromagnetic tool for non-destructive detection of buried objects. Since the beginning of the 20th century it has been used in several different areas (archaeology, landmine detection, civil engineering, ...). GPR uses the principle of the scattering of the electromagnetic waves that are radiated from a transmitting antenna. Then the waves propagate through the medium and are reflected from the object and then they are received by a receiving antenna. The velocity of the scattered signal is determined primarily by the permittivity of the material.

The optimal functionality of the GPR was investigated using the numerical simulation tool gprMax2D. This tool is based on a Finite-Difference Time-Domain (FDTD) numerical model. Subsequently, the GPR functionality was tested using the laboratory model of a decayed tree trunk. Afterwards, the results and lessons learnt in the simplified tests will be used in the processing of the real data and will help to achieve deeper understanding of them.

The laboratory model of the tree trunk was made by plastic or carton pipes and filled by sand. Space inside the model was divided into three sections to separate parts with different moisture (heartwood and sapwood) or empty space (decays).

For easier manipulation with the antenna we developed a special ruler for measuring the distance along the scans. Instead of the surveying wheel we read the distance with a camera, which was fixed on the antenna and focused on the ruler with a binary pattern. Hence, during whole measurement and the data processing we were able to identify an accurate position on the tree in view of the scan.

Some preliminary measurements on the trees were also conducted. They were performed using a GSSI 900 MHz antenna. Several tree species (beech, horse-chestnut, birch, ...) in Louvain-la-Neuve and Brussels, Belgium, have been investigated to see the internal structure of the tree decays. The measurements were carried out mainly by circumferential measurement around the trunk and also by vertical measurement along the trunk for approximate detection of the cavity. The comparison between the numerical simulations, simplified tree trunk model and real data from trees is presented.

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