Health monitoring of a matured tree using ground penetrating radar – investigation of the tree root system and soil interaction (Extended Abstract)


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# Health Monitoring of a Matured Tree Using Ground Penetrating Radar – Investigation of the Tree Root System and Soil Interaction

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***Abstract* – In this study, a demonstration of the ground penetrating radar (GPR) potential in the health monitoring of a matured tree has been given. The main objectives of the research were to provide an effective mapping of the tree roots as well as reliable simulation scenarios representing a variety of possible internal defects in terms of shape and formation. To these purposes, the soil around a 70-year-old fir tree, with a trunk circumference of 3.40 m and an average radius of 0.55 m, was investigated. A ground-coupled multi-frequency GPR system equipped with 600 MHz and 1600 MHz central frequency antennas was used for testing purposes. In addition to the above objective, finite-difference time-domain (FDTD) simulations of the electromagnetic field propagation through the cross-section of a trunk (consistent with the investigated fir tree) were carried out. A variety of defects representing cavities created due to decay were also simulated. The results from the simulations demonstrated significant potential for the interpretation of complex decay phenomena within the trunk.**

## I. INTRODUCTION

The sensibility towards environmental issues along with the attention on preserving natural heritage, especially ancient trees and rare plants, has greatly increased, and the management and control of the forestall heritage and the floral system has become accordingly a high-priority objective to achieve [1]. Within the context of non-destructive testing (NDT) techniques in forestry sciences, the ground-penetrating radar (GPR) technique has proved to be one of the most effective, due to its high versatility, rapidity in collecting data and the provision of reliable results at relatively limited costs [2, 3]. The use of GPR can provide invaluable information about the effective tree trunk assessment and appraisals, tree root mapping, soil interaction with trees and plants [4]. In addition, the use of the simulation can be a supporting tool for the development of a clear understanding of the decay processes in trees [5].

## II. AIMS AND OBJECTIVES

The aim of this research was to demonstrate and investigate the effectiveness of the GPR in the health monitoring and assessment of trees and tree roots and soil interaction.

The main objectives of the research were:

- to provide an effective method of mapping tree roots as well as to establish reliable simulation scenarios representing possible internal defects in the tree trunk (in terms of shape and formation);
- to create a set of finite-difference time-domain (FDTD) simulations of the electromagnetic (EM) field propagation through the cross-section of a tree trunk.

## III. METHODOLOGY

### *A. Investigation of the tree root system*

The soil around a 70-year-old fir tree, with a trunk circumference of 3.40 m and an average radius of 0.55 m, was investigated. 9 circular scans, 0.30 m from one another, were carried out all around the tree circumference starting from 0.50 m the outer surface of the bark. A ground-coupled multi-frequency GPR system equipped with 600 MHz and 1600 MHz central frequency antennas was used for testing purposes (Fig. 1). A swept circle area with an outer radius of 3.45 m and an inner radius of 1.05 m up to a maximum depth of 1.56 m was scanned. In order to reach the maximum penetration depth of the root system, only the 600 MHz frequency was considered for data processing purposes.

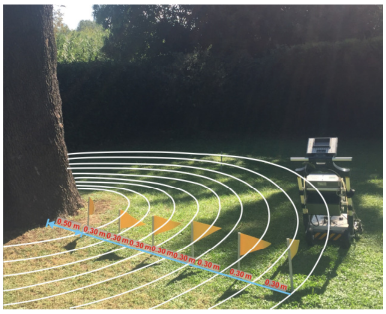

*Fig. 1. Circular scans performed around the investigated 70-year-old fir tree.*

### *B. Numerical Simulations*

In addition to the above objective, FDTD simulations of the EM field propagation through the cross-section of a trunk (of dimension consistent with the investigated fir tree) were carried out. A variety of defects representing cavities created due to decay was also simulated (Fig. 2).

## IV. MAIN RESULTS AND CONCLUSION

### *A. Investigation of the tree root system*

The data processing allowed to display the data using several visualization modes. The use of radial B-scans and tomographic amplitude maps allowed for a more comprehensive data interpretation up to depths of ~1.60 m. Visualization of the tree root system was also obtained through dedicated data processing (Fig. 3).

### *B. Numerical Simulations*

The results from the simulations demonstrated significant potential for the interpretation of complex decay phenomena within a tree trunk (Fig. 4). As an example, it was possible to observe how in the case of

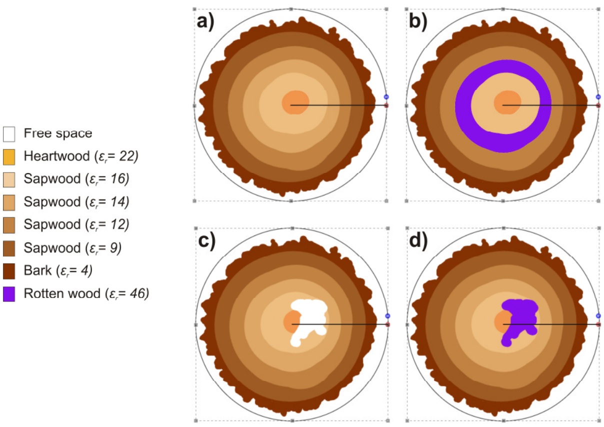


*Fig. 2. Modelled cross-section of the tree trunk: undamaged case (Scenario 0) (a); with a concentric (rotten) damage (Scen. I) (b); with an air cavity at the boundary area between heartwood/most internal ring (Scen. II) (c); with a rotten cavity at the boundary area between heartwood/most internal ring (Scen. III) (d).*

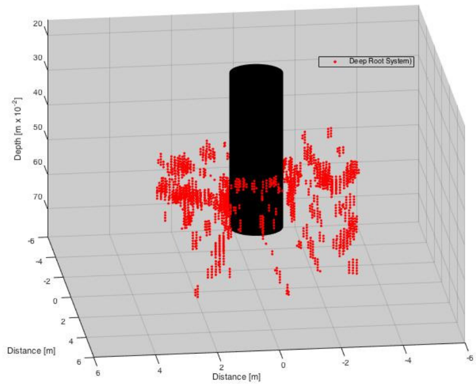


*Fig. 3. 3-D view of the tree root system.*

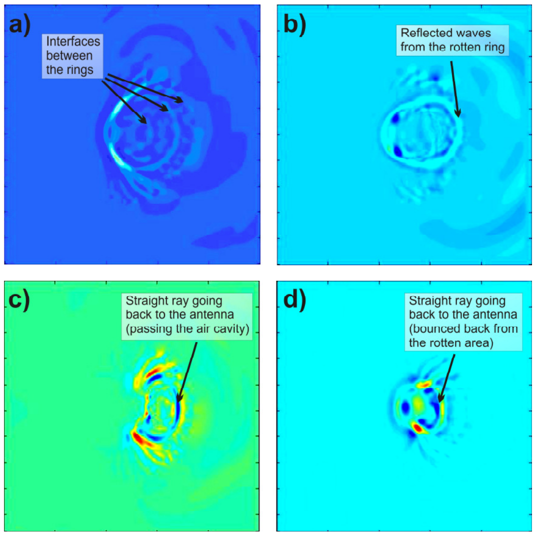


*Fig. 4. Snapshots of the electric field intensity: Scenario 0 (a); Scenario I (b); Scenario II (c); Scenario III (d).*

"rotten ring" (i.e., concentric damage) (Fig. 4b), the waves were reflected from the higher permittivity contrast, which hide the reflections from the inner rings.

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