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Abstract

Diagnosing Acute Oak Decline Using Ground Penetrating Radar †

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Emerging infectious diseases (EIDs) of trees have rapidly increase during the last 20 years due to modern socio-economic factors such as global timber trade and international travelling [1,2]. Currently, the most dominant EIDs affecting the European forests are the ash dieback [1], the Xylella Fastidiosa [3] and the acute oak decline (AOD) [4]. AOD is a bacterial infection that can lead to tree mortality within 3–5 years [4] and has rapidly spread in the United Kingdom since its first outbreak in 2012 [5]. Monitoring modern EIDs such as AOD requires new forestry approaches and modern detection schemes [2]. To this effect, ground penetrating radar (GPR) has been suggested as a diagnostic tool against AOD [5]. GPR is a non-destructive method that has the potential to detect tree-decay in a non-intrusive manner [5]. Commercial common-offset (CO) GPR systems are easily accessible and trivially deployable in the field. In addition, CO-GPR requires minimum computational and operational requirements. The above makes CO-GPR an appealing detection method for AOD especially for large-scale forestry applications [5]. The most mainstream symptom of AOD is the formation of liquid-filled chambers parallel to the main axis of the trunk [4]. The liquid-filled chambers occur predominantly between the outer sapwood and the bark. In late stages of AOD, the decay extent to the outer bark creating visible "bleeding" patches with a characteristic black colour [4]. In the current paper, we examine the capabilities of a high frequency CO-GPR system in detecting tree-decay associated with AOD, i.e. in detecting small shallow liquid-chambers within the trunk. In this context, a detection framework based on measurements collected around the circumference of the trunk is proposed [5]. First, data are accurately positioned using an arc-length parameterisation [5]. The ringing noise and the unwanted clutter are removed effectively using the singular value decomposition (SVD) method [5]. Subsequently, a reverse-time migration is applied to the filtered data in order to collapse the hyperbolas to their origins. The finite difference time-domain (FDTD) method is used to back-propagate the received reflections. The velocity of the medium is assumed to be homogenous and the permittivity is evaluated using auto-focusing criteria [6]. Lastly, the migrated images are smoothed using a Gaussian blur filter and subsequently squared to further enhance the resulting signal [7]. The viability of the suggested scheme has been proven successfully with numerical, laboratory and on-site tests, indicating that GPR is a commercially appealing methodology for diagnosing early symptoms of AOD.

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