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Giannakis, Iraklis, Alani, Amir, Lantini, Livia ORCID: <https://orcid.org/0000-0002-0416-1077>,
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Abstract

Diagnosing Acute Oak Decline Using Ground Penetrating Radar [†]

Iraklis Giannakis ^{1,*}, Amir M. Alani ¹, Livia Lantini ¹, Dale Mortimer ² and Fabio Tosti ¹

¹ School of Computing and Engineering, University of West London (UWL), St Mary's Road, Ealing, London W5 5RF, UK; Amir.Alani@uwl.ac.uk (A.M.A.); Livia.Lantini@uwl.ac.uk (L.L.); Fabio.Tosti@uwl.ac.uk (F.T.)

² Tree Service, London Borough of Ealing, Perceval House, 14-16 Uxbridge Road, Ealing, London W5 2HL, UK; MortimerD@ealing.gov.uk

* Correspondence: Iraklis.Giannakis@uwl.ac.uk

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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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References

1. Broome, A.; Ray, D.; Mitchell, R.; Harmer, R. Responding to ash dieback (*Hymenoscyphus fraxineus*) in the UK: woodland composition and replacement tree species. *For.* **2018**, *92*, 108–119.
2. Santini, A.; Ghelardini, L.; De Pace, C.; Desprez-Loustau, M.L.; Capretti, P.; Chandelier, A.; Cech, T.; Chira, D.; Diamandis, S.; Gaitniekis, T.; et al. Biogeographical patterns and determinants of invasion by forest pathogens in Europe. *New Phytol.* **2012**, *197*, 238–250.
3. Janse, J.D.; Obradovic, A. *Xylella Fastidiosa*: Its biology, diagnosis, control and risks. *J. Plant Pathol.* **2010**, *92*, S1.35–S1.48.
4. Brown, N.; Inward, D.J.G.; Jeger, M.; Denman, S. A review of *Agrilus biguttatus* in UK forests and its relationship with acute oak decline. *Forestry* **2014**, *88*, 53–63.
5. Giannakis, I.; Tosti, F.; Lantini, L.; Alani, A.M. Health Monitoring of Tree Trunks Using Ground Penetrating Radar. *IEEE Trans. Geosci. Remote. Sens.* **2019**, *57*, 8317–8326.
6. Giannakis, I.; Tosti, F.; Lantini, L.; Alani, A.M. Diagnosing Emerging Infectious Diseases of Trees Using Ground Penetrating Radar. *IEEE Trans. Geosci. Remote. Sens.* **2019**, 1–10, doi:10.1109/TGRS.2019.2944070.
7. Giannakis, I.; Tosti, F.; Lantini, L.; Egyir, D.; Alani, A.M. Signal Processing For Tree-Trunk Investigation Using Ground Penetrating Radar. In Proceedings of the 10th International Workshop on Advanced Ground Penetrating Radar, EAGE, The Hague, The Netherlands, 11 September 2019; pp. 1–5.



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