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Use of three-dimensional ultrasonic tomography to detect decay in a living adult holm oak (Quercus ilex l.) in Sardinia (Italy)

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Due to recent human activity many holm oak trees (Quercus ilex L.) are planted in the public and private gardens in Sardinia. At present many of these trees are afflicted by decay especially that caused by pathogenic fungi which produce tail disease and bark cancer. A field methodology using ultrasonic tomography supported by a digital photogrammetry survey has been developed and evaluated as a tool to detect the presence and patterns of internal decay in a living adult holm oak tree.
Ultrasonic methods are commonly used to detect the elastic characteristics and thus the dynamic properties of different materials (e.g. stone, concrete, wood) although the interpretation of the data is very complex because elastic wave propagation strictly depends on the heterogeneity, the porosity and other material properties. Weak materials, the presence of fractures or decay zones, small cavities, and cracks within the materials are potential defects characterized by low ultrasonic velocity compared to the velocity in healthy materials. In this sense, ultrasonic velocity can be used effectively as one of the main diagnostic physical parameters to detect internal decay and define the healthy state of the investigated holm oak stem with diameter at breast height (DBH) of 32 cm.
In this study, considering the nature and size of the investigated tree and the target of the study, an ultrasonic investigation by the three-dimensional ultrasonic tomography technique was carried out at 24kHz . The ultrasonic measurements were performed in situ using the portable ultrasonic non-destructive digital indicating tester (PUNDIT Lab plus) by Proceq (Schwerzenbach, Switzerland) and piezoelectric transducers. Silicone snug sheets were chosen as the coupling agent because they provided the best contact transducer material as deduced from many tests.
The travel time of the longitudinal elastic waves was measured along a large number of measurement paths between stations located on the perimeter of the stem. Each station was alternatively used as a transmitter and a receiver. The sector of the stem was criss-crossed by a large number of discrete rays. Each ray between stations was divided into small segments, each corresponding to a pixel element. The travel time of the longitudinal ultrasonic signals along the source-receiver ray paths was recorded together with the relative position and orientation of each ray. The ultrasonic data volume was processed by specific software exploiting appropriate reconstruction algorithms to obtain a three-dimensional representation of the distribution of the longitudinal wave velocity inside the stem. Results show that ultrasonic tomography may be an effective tool for a high accuracy evaluation of the internal decay of the investigated tree and for monitoring its conservation state.
KEY WORDS: Holm oak, ultrasonic tomography, decay detection, monitoring.