Close Range Photogrammetry and NDT imaging techniques for the characterization of timber structural elements

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Abstract Visual grading criteria correlate mechanical properties of timber with visual features, such as growth characteristics, surface decay and geometrical defects that can affect these properties. In order to reduce the subjectivity of the results and optimize the procedure, automatic wood inspection systems, based on optical log scanning and automatic detection of defects, have been developed for the wood industry. More accurate results can be achieved if optical scanning of external features is coupled with internal log scanning. For this purpose, non-destructive imaging techniques are used, which permit to obtain information about non visible internal defects. Recently, thanks to the availability of portable equipment, application of imaging techniques for the inspection of timber members in service has been proposed. In the normal praxis, however, inspection on site is generally based on visual analysis, supported by local mechanical non-destructive tests for the detection of internal decayed areas.

In the research presented in this paper, the combined use of close range photogrammetry, to map and measure external features, and acoustic tomography, to detect internal defects of wood, is proposed for the characterization of structural timber on site.

Time of flight (TOF) acoustic tomography was carried out, using a multichannel acquisition device and a piezoelectric transducer with a central frequency of 55 kHz, for emitting ultrasonic signals.

A software for the tomographic inversion was used that combines both iterative and direct inversion techniques.

A non-metric CCD medium format digital camera (Hasselblad H3DII-39) has been used, for high resolution acquisition of the images of the specimen faces. Nominal parameters (focal length, principal point coordinates and distortions) given by the manufacturer were considered for the interior orientation of the camera.

In order to produce detailed maps of wood strength affecting characteristics on the element surface, commercial software Photomodeler® was used to extract orthographic photomaps from the acquired images of the wood surface texture.

Images of the material texture on the element faces, rectified and scaled by means of the photogrammetric procedure, have been analyzed using image analysis techniques.

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Also tomograms, represented by 256 levels of grey images, where the white level corresponds to the maximum velocity, and the black level corresponds to the minimum velocity, have been post-processed, for a better interpretation of results.
Segmentation algorithms were applied to isolate the areas of interest on the image, and divide it into different regions, corresponding to the selected material features.
Once images have been segmented and the different material features have been labeled, a series of proprieties of the extracted features could be calculated, such as the area of the different external features, the maximum knot diameter and knot distance from the edges, the inclination of checks and global slope of grain, etc.
While photographic images permits to obtain reliable metric information, quantitative analysis of acoustic tomograms is limited by the inherent resolution and the difficulty of distinguishing between the natural structure of the material and its pathological features.
From image data, geometrical data of the detected features have been extracted, for further analysis.
Segmented data boundaries were fitted by two-dimensional contouring using B-spline curves.
From the boundary curves and information of internal heterogeneities given by tomography, 3D modeling of features can be carried out (Fig.1 and Fig.2).
In the oingoing research, effects of knots are modeled from the analysis of grain and growth layer patterns on the element faces through simulation of local deformation of the growth surfaces.
Geometrical data of the detected features can be used to implement a procedure to model domain geometry in the numerical analysis of wooden elements, taking into account the intrinsic variability of the material. In this case, so called “morphology-based models” are developed, to represent selected structural features of the material.

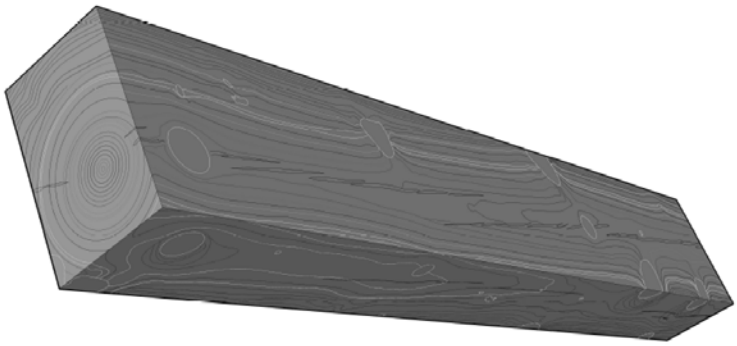

Figure 1 – Geometrical model of the external features on the timber element

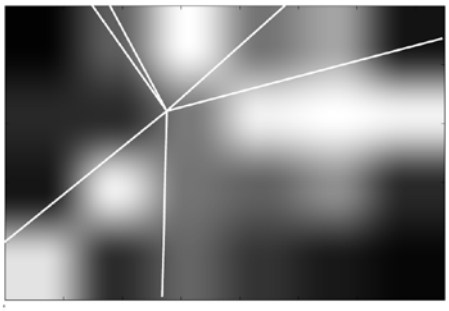

Figure 2 –Tomogram of a RT section and, superimposed, deduced knot profiles

Keywords Timber characterization, digital photogrammetry, sonic tomography, image analysis, geometrical modeling

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