Sweep Source Optical Coherence Tomography (SS-OCT) for the examination of dry and waterlogged "heritage" wood

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OCT has been under development over the past few years in increasing numbers of applications for the diagnosis of art objects, such as stratigraphic applications, varnish layer analysis, other structural analysis and profilometric applications.[1-9] Nevertheless, present and potential applications of OCT to diagnostics and documentation of art objects, are still seeking for a subject best served by the method and further significant progress will only be possible if the method becomes widely adopted by conservation scientists and researchers.[5,9]

In this project, a Thorlabs-OCS1300SS sweep source optical coherence tomography (SS-OCT) setup with a single photodiode was used. The central wavelength of the setup is 1325 nm with a spectral bandwidth of 100 nm. The coherence length is 6 mm and the maximum imaging depth, depending on the refraction of the material, is 2 to 3 mm.[10]

Scanning was performed on dry and waterlogged fresh and archaeological samples without processing or sectioning as well as samples thin-sectioned by hand with a razor blade. Since cross-sectional images are generated by measuring the echo time delay and intensity of light reflected or backscattered from the internal structure[11], moisture content seems to play a fundamental part in imaging. 2D and 3D imaging was exported by Thorlabs 3D Builder, "3D swept display" software.[12]

High resolution, detailed cross-section views of the samples were provided in all planes -Transverse (TR), Radial (RAD), Tangendial (TAN)- allowing surface topography and internal anatomical information, such as growth rings boundaries, pores, rays, patterns, tyloses etc., to be differentiated. Dimensions measured were used to export qualitative and quantitative anatomical information.

3D imaging enabled the sample to be interpreted in 3D space, which strongly influenced its topographical representation and illustrated quantitative morphometric investigation of wood surface and structure. Export of animations is also supported.

Data processing of 2D and 3D imaging was also used to support quantifications based on the analysis of real physical parameters. Thus, physical properties like moisture content and water movement, as well as their associated effects were most likely visualized and quantified. Variations associated with them through time, such as changes in thickness, width, distances between characteristic points, volume of chosen structures etc., possibly assessed values of specific physical parameters. Results were displayed as contour maps, with labeling associated to the various changes.[13]

Except successive 2D images in time, high speed SS-OCT enabled 4D imaging (3D in time). This approach probably offered opportunities to monitor dynamic changes in wood properties and structure, p.e. due to drying. Examples of 4D can only occur though, when an entire scanning protocol is repeated in time, giving real-time volumetric reconstruction of the structure.[13]

Statistical Parametric Mapping (SPM) data analysis was carried out with the Free - Open source software "Gwyddion 2.31", (covered by GNU General Public Licence), developed by the Czech Metrology Institute as a modular program for 2D and 3D data analysis.[14]

2D or 3D contour maps obtained from SPM analysis of 3D OCT data have two basic advantages: first they enable a quick assessment of the condition of the structure without the necessity of studying

cross-sectional images successively. Second, each of the contour maps is created based on a physical value, thanks to which the statistical specificity of a given analysis can be increased.[13]

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