EVALUATION OF ABSOLUTE DISPLACEMENTS IN BIOLOGICAL TISSUES USING TOPOLOGICAL SKELETONS OF MULTI-DIMENSIONAL OPTICAL COHERENCE TOMOGRAPHY RAW DATA

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A method for highly accurate evaluation of absolute displacements in soft biological tissues using optical coherence tomography (OCT) and elastography (OCE) was presented. The main purpose of the proposed method is to correct artifacts of the volumetric movement of the scanning probe and biological tissue relative to each other, but it is also suitable for directly evaluation of the biomechanical properties of soft biological tissues.

The proposed method includes the following main steps: I) formation of a series of sequential structural images based on the amplitude (vector lengths) of complex OCT or OCE signals; II) generation of a topological skeleton for each «amplitude image»; III) creation of test points on topological skeletons in accordance with the FAST algorithm using descriptors found using the BRISK algorithm (using the FREAK algorithm is also acceptable); IV) grouping of test points taking into account match scores (ideally building a homography matrix); V) calculation of displacement vectors for all groups of test points; VI) interpolation of a sparse vector field to fit the dimension of the original optical images; VII) selection of the most convenient (requiring the least compensation of volumetric movements) for subsequent analysis of images from the series under consideration; VIII(a) compensation of volume motion artifacts by reassembling the arrays of raw data with lateral shifts and (if necessary) partial rotations by small angles; VIII(b) in the case of absence significant volumetric displacements of the biological tissue and the probe relative to each other, but the presence of a deforming effect differential between the analyzed images, the interpolated vector field is a simple elastogram.

The proposed method was practically implemented using the LabVIEW environment and tested using the «OCT1300-E» system («BioMedTech», Nizhny Novgorod, Russia). Laboratory experiments with tissue-simulating phantoms with a known structure showed a more than threefold decrease in the severity of volumetric motion artifacts. In some experiments, it was possible to compensate for nonlinear (both in velocity and in angle) horizontal shifts up to 1/3 of the scanning area. The effect obtained is due to the combination of the high efficiency of used raw data acquisition system and high resistance of topological skeletons to various noises.

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