MOTION ARTIFACTS CORRECTION FOR IMPROVING THE EFFICIENCY OF OPTICAL COHERENCE ELASTOGRAPHY

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Optical coherence tomography (OCT) and elastography (OCE) have many unique diagnostic capabilities, in particular, micron spatial resolution, relative harmlessness of probing irradiation, relatively small dimensions and reasonable cost of equipment, etc. One of the difficulties limiting the ubiquitous application of OCT methods and especially OCE in real clinical practice is the high sensitivity to volumetric movements. In the case of the spatial resolution of the OCT system equal to conventional 10 microns, even a tremor of the user's hand (a medical or scientific worker) is enough for the images obtained by means of a scanning probe to constantly shift. The high acquisition rate allows for stable B-scans, but when it comes to sequences of B-scans (for example, with different levels of deforming effects in the OCE), volumetric motion artifacts become a problem. Classical approaches to compensating movements on the homography matrix are not very efficient for OCT and OCE due to the presence of speckle noise.

Due to the above, a special method for correcting volumetric motion artifacts was developed, which includes the following main steps: I) the formation of a series of sequential structural OCT or OCE images; II) binarization of all processed images in favor of dark pixels according to the first threshold level corresponding to the minimum intraclass dispersion between dark and light pixels; III) the obtained arrays are independently subjected to the fast Fourier transform, the lower frequencies are truncated at the second threshold level; IV) the inverse fast Fourier transform returns the signal to the time domain, where it undergoes several iterations of morphological erosion; V) the topological skeleton for each image is constructed as a set of thin lines equidistant from the formed areas of the equivalent high-level signal; VI) topological skeleton is used for robust comparison of OCT or OCE images, e.g., by test points; VII) volume motion artifacts are corrected by reassembling the original complex data, in particular, adding or removing data columns, shifting rows (including with small-angle rotation); VIII) structural and (if necessary) functional OCT-images are generated from the reassembled data.

The proposed method was practically implemented in the LabVIEW environment. A series of laboratory experiments with tissue-mimicking phantoms showed the fundamental possibility of compensating for nonlinear (both in velocity and in angle) horizontal shifts of up to 1/3 of the scanning area, which in turn corresponds to situations, which typical of real clinical practice, when the scanning probe is not rigidly fixed relative to the biological tissue under study.

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