DETECTION AND CORRECTION OF PHASE DISCONTINUITY IN THE INTERFERENCE SIGNAL OF OPTICAL COHERENCE TOMOGRAPHY USING THE HOUGH TRANSFORM

Anton Yu. Potlov, Kristina S. Savinova

Russia, Tambov State Technical University, Department of Biomedical Engineering

E-mail: zerner@yandex.ru

The interference signal of optical coherence tomography (OCT) is quite often presented in a complex form, where the real part corresponds to the cosine quadrature of the signal, and the imaginary part corresponds to the sine one. The magnitude of the amplitude of each sample of the interference signal is calculated as the modulus of the complex signal (the length of the corresponding vector), and the phase is calculated as the argument (the angle between the vector and the positive direction of the real axis) of the same complex signal. Amplitude information is of paramount importance in structural OCT imaging, and phase is usually analyzed in more depth as phase shifts are associated with movements and deformations. However, if the phase shift reaches 2π, ambiguity arises in the interpretation of the data. The above uncertainties are eliminated by phase unwrapping based on the assumption that the true phase values for two successive samples of the same A-scan are close to each other. So, the phase difference can be brought to range by adding or subtracting the n-th integer number of periods. However, the true phase values for two successive samples in some cases (for example, severe deformations, severe volumetric movements and especially the superposition of the above factors) can be quite different. This causing phase unwrapping failures. Interframe phase difference is much more stable in this regard, but also needs to be disambiguated.

The method of phase unwrapping within one column of the data array, taking into account information from all neighboring columns, was presented in connection with the above. In particular, discontinuities in phase for the entire phase image are proposed to be detected using the Hough transform. The above discontinuities with this approach will be a set of curves of a given family, the criterion for belonging to which is the phase contrast between adjacent readings above the threshold level. Further, information about the geometry of phase discontinuity for the entire data array as a whole is used as a priori information when unwrapping the phase for the current column. The phase ambiguity is removed in a classical way in the case a 2π-uncertainty in the interpretation of the phase shift is detected in the current sample of the current column and a priori information indicates that the sample corresponds to an extended phase discontinuity section («rainbow stripe») on the corresponding image. The 2π-uncertainty is recognized caused by noise in other cases.

The proposed method was practically implemented by using the LabVIEW software package. A series of experiments with the deployment of interline and interframe phase changes showed an increase in the reliability of the obtained interferograms by at least 14%.

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