ARTIFICIAL INTELLIGENCE TOOLS FOR IMAGE RECONSTRUCTION IN LOW-DOSE X-RAY BREAST COMPUTED TOMOGRAPHY

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In recent years, digital breast tomosynthesis (DBT) [1] has been used increasingly often for breast cancer diagnosis and monitoring. DBT implements the method of computed tomography and resolves the shade overlapping problem inherent in traditional X-ray mammography. With steered beam technology [2] and polycapillary x-ray sources [3] it becomes principally possible to bring DBT to a higher qualitative level and implement plane-layer geometry where breast is clipped between two plates with submillimeter sources and detectors. Steered beam and polycapillary technologies allow a narrow ray from any source to be directed to any detector. Thus the most important DBT problem of dose optimization for patients is solved through minimization of rays rather than minimization of views as in fan-beam or cone-beam tomography.

Our objective is to develop an image reconstruction algorithm which would allow the total number of rays to be reduced by a few times without making the quality of tomograms degrade. At this phase of research we limit ourselves to 2D geometry, reconstruction of binary images, and a minimal inhomogeneity (tumor) 1 mm in size. Our algorithm includes three stages. The first is aimed to determine a minimal set of rays required for the initial localization of the inhomogeneity. For this purpose we use a genetic algorithm [4]. All crossing and mutation operators we have developed are described in the paper in rather detail. The second stage solves inhomogeneity localization with the algebraic reconstruction technique (ART) [5] in combination with median filtration [6]. At the third stage the minimal set of rays is extended to include the rays that pass through the localized inhomogeneities and a hybrid algorithm is applied for more accurate reconstruction. The hybrid algorithm implements an iterative procedure where the ART works first and then its results are filtered with use of a convolutional neural network of U-Net architecture [7] for attaining regularization and better reconstruction accuracy.

The efficiency of the proposed algorithm is demonstrated by numerical experiments on the reconstruction of phantoms with breast tumor models. In the reconstruction of 2–3 tumors, we managed to reduce the number of rays by about 3–5 times and reproduce the shape of the tumors rather accurately. Possible modernizations of the algorithm are discussed in conclusion.

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