POLITECHNIKA ŚLĄSKA W GLIWICACH
WYDZIAŁ INŻYNIERII BIOMEDYCZNEJ

Multimodalny system śledzenia i rejestracji w zabiegach biopsji gruboigłowej gruczołu sutkowego

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Abstract of the thesis:

Multimodal tracking and registration system for core needle biopsy procedure of mammary gland

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Doctoral dissertation entitled Multimodal tracking and registration system for core needle biopsy procedure of mammary gland is a monographic approach to the important issue of supporting a radiologist during core-needle biopsy of the mammary gland (CNB), which is one of the most important procedures in the process of oncological diagnostics. Correct collection of tissue fragments, which translates into diagnostic accuracy, requires precise insertion of a biopsy needle into a specific lesion zone. The physician performing the biopsy uses a two-dimensional, noisy ultrasound image (US), in which the boundaries of the lesion are not clear, and the visualization of the needle is not always correct. The needle is clearly visible only when it is completely in the plane of the image. If the stylus is parallel to the stylus face, there is a strong mirror image which improves the stylus image quality but may cause reverberation artifact. In addition, adjacent, distinct longitudinal, anatomical structures (e.g., fascia borders) may make it difficult to correctly position the needle in the image.

The presented dissertation describes the radiologist's support system with algorithms for detecting and segmenting structures in ultrasound images. The proposed proprietary data registration system was used to acquire 204 CNBs from 33 oncological patients at the Department of Radiology at Maria Skłodowska-Curie National Research Institute of Oncology – Gliwice Branch. From the recorded clinical data, two new image sets were created containing an image content label and an expert outline: *(i)* lesion and healthy tissue, and *(ii)* biopsy needle.

The collected clinical data, extended by publicly available image databases, were the basis for proposing and validating proprietary methods of classification and segmentation biopsy needle and lesion in two-dimensional ultrasound images of the mammary gland.

The first of the methods is the proposal of a proprietary architecture based on convolutional neural networks (CNN) used to classify the content of images in terms of *(i)* the visibility of the biopsy needle and *(ii)* the presence and type of lesion. Another original element is the proposal of a method for determining the trajectory of the biopsy needle using the Radon transform performed as a result of semantic segmentation of the object with the author's CNN-based architecture. The last element of the methodology is the segmentation of the lesion using the classic methods: active contour, gradient vector flow snakes, the region growing method and the watershed algorithm, the results of which are aggregated by a ensemble approach.

Evaluation of the elements of the proprietary multimodal tracking and registration system for core-needle biopsy of the mammary gland shows high accuracy of the data recording system, it is characterized by competitive efficiency with a shorter operation time in terms of image content classification compared to known architectures: AlexNet, VGG16, VGG19, SqueezeNet, GoogLeNet, ResNet101 and InceptionResNetV2. Statistical analysis of trajectory errors showed the comparability of the author's method of trajectory estimation with expert images and showed an advantage over the methods of Hatt et al. and Lee et al., which were also based on clinical data. Evaluation of the measures of lesion segmentation by the ensemble also showed higher efficiency than the independent use of each of the classical methods.