Abstract

The goal of this Ph.D. thesis was to develop and propose novel methods for locating the centers of anatomical features on fundus images: fovea and optic nerve disc. The study used two strategies: an approach based on image processing techniques and shape analysis and an approach using advanced deep neural networks, transfer learning, and ensemble learning.

In the evaluation of methods for locating the centers of objects, such as neural networks or AI techniques more generally, performance measures such as accuracy and coverage are used. Accuracy is expressed as the average Euclidean distance (*pol. Średni Błąd Euklidesowy, SBE*) between the locations of the measures determined by the expert and by the method: $SBE = \sqrt{\frac{\sum_{i=1}^{n}(\hat{y}-y)^2}{n}}$, where $\hat{y}$ – coordinates of the center of the object determined by the expert, y – coordinates of the center determined by the method, n – number of determined centers. Coverage is the percentage of the number of object centers determined by the method relative to the number of centers determined by the expert: $coverage = \frac{number\ of\ centers\ determined\ by\ the\ method}{number\ of\ centers\ determined\ by\ the\ expert}$.

In applying the first approach, the focus was on using generic image processing algorithms. Shape analysis methods were also applied to increase the efficiency of identifying anatomical features of the retina with characteristic structure. This approach proved effective in terms of efficiency and the resources used but showed some limitations in the context of the varying exposure conditions of the image.

In the second approach, deep neural networks were used, due to their high ability to extract complex patterns found in images. Transfer learning was also implemented to use the knowledge gathered from other datasets. The use of ensemble learning effectively increased the overall performance of the proposed method. In comparison with the first approach, deep neural networks better cope with varying conditions and shapes but require larger computational and time resources.

A series of tests were performed to compare the efficiency and resource consumption of the developed methods. The evaluations included precision and location coverage, computational efficiency, memory consumption, and execution time of the methods in sequential and parallelized modes. The

results showed that the method based on deep neural networks achieved higher efficiency and better ability to deal with various conditions at the cost of higher resource consumption.