WARSAW UNIVERSITY OF TECHNOLOGY

FACULTY OF MATHEMATICS AND INFORMATION SCIENCE

Ph.D. Thesis

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Computer-aided image-based diagnosis: extensions of computational models with domain knowledge

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Abstract

This dissertation presents machine learning methods to support image-based medical diagnosis. The work presents research results regarding the limitations of the effectiveness of machine learning methods in selected applications. The dissertation includes nine publications which review the concepts related to deep learning in radiology, investigate challenges in training robust machine learning models supporting image-based medical diagnosis, and describe methods to enhance their effectiveness in the context of real-world utility in important applications.

The first publication discusses general challenges and growing potential of the applications of deep learning methods and models supporting image-based diagnosis, emphasizing issues related to data availability, model validation, collaboration with clinicians, and obstacles to effectively integrate deep learning into radiology practice. The second publication investigates the class imbalance problem in training convolutional neural networks. The following publications focus on specific projects and applications that investigate these two challenges and propose solutions to overcome them.

The next two publications are devoted to applications in brain magnetic resonance imaging (MRI), where the first focuses on the segmentation of brain MRI with a highly imbalanced distribution of target classes and the second investigates the benefits of transfer learning in radiogenomics.

The following three publications are related to applications of machine learning methods in supporting thyroid diagnosis using ultrasound, where the first shows how approximate annotations can be used to extend the training data size for ultrasound images, the second describes the implementation of a system for autonomous diagnosis of thyroid nodules, and the last publication in this group describes the optimization of a guideline system for the interpretation and diagnosis of thyroid nodules in ultrasound images.

Finally, there are two publications for applications in digital breast tomosynthesis (DBT), where the first introduces a publicly released DBT dataset together with a baseline model, and the second proposes a method based on image-completion using generative adversarial networks which utilize only examples without lesions for abnormality detection.

Keywords: computer-aided diagnosis, machine learning, radiology, medical imaging, convolutional neural networks, deep learning, transfer learning, class imbalance, generative adversarial network, brain MRI, thyroid ultrasound, digital breast tomosynthesis, radiogenomics