**Doctoral School of Information and Biomedical Technologies**
**Polish Academy of Sciences (TIB PAN)**

**SUBJECT: Artificial Intelligence-based automatic segmentation of medical imaging in cancer diagnostics**

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Name of the institute in which the topic will be realized: **Institute of Fundamental Technological Research**

Scientific discipline: **Information and communication technology**

## PROJECT DESCRIPTION

Early pancreatic cancer diagnosis and therapy drastically increase the chances of survival. Tumor visualization using scan images, including computed tomography (CT) and magnetic resonance imaging (MRI) is an important part of these processes [1]. Organ and vessel **segmentation with subsequent 3D visualization** enhancement can substantially improve planning, reduce the incidence of unforeseen intraoperative decision-making, and improve clinical outcomes. The segmentation procedure is done usually manually, with an expert setting in front of a monitor moving a pointer, and not only this requires time and resources to accomplish, but it is also subjected to error depending on the experience of the expert. Many organs are difficult to segment due to their shape, position, and significant variability, which may result in blurred boundaries [2]. Some of the organs take up a small space of an entire CT image scan. Moreover, the often the border between the desired organ and background is very subtle making it especially challenging to precisely define its boundaries. Thus, precise segmentation of lesions may contribute to efficient diagnostics and more effective, targeted therapy or surgical planning.

On the other hand, **Artificial Intelligence (AI)** has the potential to revolutionize the analysis and interpretation of medical data, in particular in the area of diagnostics at the early stage of cancer development, assessment of its advancement at any time. AI-based algorithms, especially, deep neural networks (DNNs) have revolutionized image segmentation [3-6]. The most commonly used AI-based algorithms in image semantic segmentation, in particular in the segmentation of different tumors, are Convolutional Neural Networks (CNNs) [7] like the U-Net [8], and its variation U-Net++ [9], R2UNet [10]. Medical image processing is time-consuming, especially when the image is of poor quality. Moreover, the participation of humans is needed. Thus, the development of efficient and accurate segmentation algorithms is of high importance.

The **Doctoral Thesis aims** to develop and implement **new effective segmentation algorithms based on Artificial Intelligence**, in particular**, Machine Learning techniques**. Such algorithms should allow effective and accurate perform automatic segmentation of the organ and its abnormalities and should provide a classification of the lesion and visualize the organ and its abnormalities. For example, in the case of classical learning algorithms the important problem is devising data-driven feature extraction mechanisms (like a **set of prespecified filters**). In the case of **deep learning networks**, although network weights are often specified automatically by backpropagation and stochastic gradient descent methods, **they require a lot of hyperparameters tuning** (such as number layers, regularization coefficients and dropout coefficients) which are most often selected with heuristic decisions. The teaching and testing dataset will be constructed based on MRI/CT scans combined with 3D images from patients. The dataset will be based on **public, retrospective datasets** (like, for example, Edgar) and from **data obtained from our partners** (*University Medical Center Utrecht, Peacs BV, Nieuwerbrug aan den Rijn, the Netherlands, and Denmark Aalborg University*).

## BIBLIOGRAPHY

[1] Sim, S.H., et al. (2009). The role of PET/CT in detection of gastric cancer recurrence, BMC Cancer 9(1), 73. [2] Dai, S., Zhu, Y., Jiang, X., Yu, F., Lin, J., & Yang, D. (2023). TD-Net: Trans-Deformer network for automatic pancreas segmentation. Neurocomputing, 517, 279-293. [3] Chen, L. C., et al., (2018). DeepLab: Semantic Image Segmentation with Deep Convolutional Nets, Atrous Convolution, and Fully Connected CRFs. IEEE Trans Pattern Anal Mach Intell, 40(4), 834-848. [4] Polyviou, A., & Zamani, E. D. (2023). Are we Nearly There Yet? A Desires & Realities Framework for Europe's AI Strategy. Information Systems Frontiers, 25(1), 143-159 [5] Hasan, M. M., Islam, M. U., Sadeq, M. J., Fung, W. K., & Uddin, J. (2023). Review on the Evaluation and Development of Artificial Intelligence for COVID-19 Containment. *Sensors (Basel)*, *23*(1) [6] Chen, P. T., et al., (2023). Pancreatic Cancer Detection on CT Scans with Deep Learning: A Nationwide Population-based Study. Radiology, 306(1), 172-182. [7] Badrinarayanan, V., Kendall, A., & Cipolla, R. (2017). SegNet: A Deep Convolutional Encoder-Decoder Architecture for Image Segmentation. IEEE Trans Pattern Anal Mach Intell, 39(12), 2481-2495. [8] Li, X., et al., (2020). Multi-Task Refined Boundary-Supervision U-Net (MRBSU-Net) for Gastrointestinal Stromal Tumor Segmentation in Endoscopic Ultrasound (EUS) Images. IEEE Access, 8, 5805-5816. [9] Zhou, Z., et al., (2018). UNet++: A Nested U-Net Architecture for Medical Image Segmentation. In Deep Learning in Medical Image Analysis and Multimodal Learning for Clinical Decision Support Cham. [10] Alom, M. Z., Yakopcic, C., Hasan, M., Taha, T. M., & Asari, V. K. (2019). Recurrent residual U-Net for medical image segmentation. J Med Imaging (Bellingham), 6(1), 014006.