Generalized Saliency Prediction for the Segmentation of Biomedical Images

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Abstract: The recent interest for artificial intelligence (AI) can mostly be explained by the success of deep learning techniques especially in computer vision. State-of-the-art methods based on deep neural networks can obtain good results when applied to biomedical images for tasks such as pattern recognition, object detection and segmentation. Unfortunately, all these methods require a large amount of good-quality annotated training examples to provide efficient prediction models. The specificity of biomedical applications, is that obtaining annotated is often complicated due to ethical issues about medical private information. Moreover, obtaining reliable annotations from specialists is often long and very expensive. Hence, this thesis addresses the problem of developing generalized saliency prediction models for image segmentation to deal with the problem of insufficient training dataset. Our aim is to develop and assess in real-world application scenarios (e.g. tumor segmentation), several learning paradigms related to Human perception, transfer learning and data augmentation.

Scientific problem

Deep learning is beginning to have an impact in biological research and biomedical applications due to its capability to deal with large dataset, to extract new features and to consider the existing knowledge [7]. However its efficiency strongly depends on the amount of available training data that can be complicated in very specialized tasks such as thrombus identification from stroke Magnetic Resonance Imaging (MRI) [9, 5]. Such tools can significantly help clinicians and regulators to make the good decision that could be decisive for saving the life of a patient.

Considering the problem of image segmentation from biomedical imaging, most of the state-of-the-art methods based on machine learning use task-specific annotated datasets. It result is a huge number of methods based on similar Deep Neural Network (DNN) models but trained using task-specific datasets [6]. Moreover, clinicians which are the only ones responsible for medical decision making, require assistance tools to highlight the region of interest in an image.

The difficulty to obtain a sufficient amount of reliable task-specific biomedical training data for a supervised automatic approach requires to investigate new strategies. In fact, the physiological information of each patient can be secret or unavailable and the reliable annotations provided by a specialist can be long and expensive to obtain.

One solution suggested by very recent studies [11] proposes to develop new generic saliency functions based on the general behavior of radiologist which is able hierarchically organize the information in an image to identify a large amount of a pathologies from different kind of biomedical images with different modalities. The idea of extracting areas of interest from biomedical imaging has already shown its usefulness [13] and could benefit of being actualized using a deep neural network approach. Indeed, merging features to model

the Human attention system [4] continue to gain interest with recent works such as [10] and begins of being exploited by early new deep learning architectures through attention-based models [3].

Hence, the goal of this thesis is to develop new deep learning paradigms leading to generalized biomedical image saliency function.

Proposed methodology

This thesis focuses on the biomedical image segmentation problem for which a large number of state-of-the-art supervised methods based on DNN exist and can obtain efficient results with a sufficiently large training dataset. The main purpose here consists in dealing with the configuration where the number of annotated examples is insufficient to successfully train a DNN model. With this in mind, the PhD candidate will develop, combine and compare several new approaches to address this complicated configuration. Among the proposed solutions:

- Developing new generalized saliency models based on Human perception [11].
- Proposing new methods to efficiently extract common features used by different segmentation tasks through transfer learning [12].
- Investigating efficient data augmentation techniques to improve the robustness of models and to increase the size and quality of training dataset by considering adversarial training [8] and adversarial poisoning [2].

For each proposed approach, an effort is expected for analyzing and understanding the meaning of the relevant features and representations designed for estimating the areas of interest in a MRI.

Related works

- PhD Thesis of Jonathan Kobold (supervised by H. Maaref and V. Vigneron) on thrombus detection and segmentation from MRI (PhD defended in Feb. 2020) [5].
- Master thesis of **Ikram Brahim** (supervised by **D. Fourer in collaboration with H. Maaref and V. Vigneron**) on tumor segmentation from MRI using deep learning (Feb. 2019 - Sept. 2019) [1].
- Master thesis of Andrea Roncoli on biomedical image segmentation (Feb. 2019 - Sept. 2019).

Required profile

- good machine learning and signal processing knowledge
- mathematical understanding of the formal background
- excellent programming skills (Python, Matlab, C++)
- good motivation, high productivity and methodical works
- an interest for AI and biomedicine

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