Master position 2020- 2021

Deep predictive modeling of cancer imaging based on weak supervision and atypical losses

Host laboratory : Laboratoire CREATIS, 69 Villeurbanne- MYRIAD Team
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Keywords : Medical Image analysis and Modeling, Deep Learning, Diagnosis model, weakly supervised learning
Duration : 6 months.
Starting date : Autumn or Winter 2020-21
Gratuity $\sim$ 560 euros/month

Scientific context

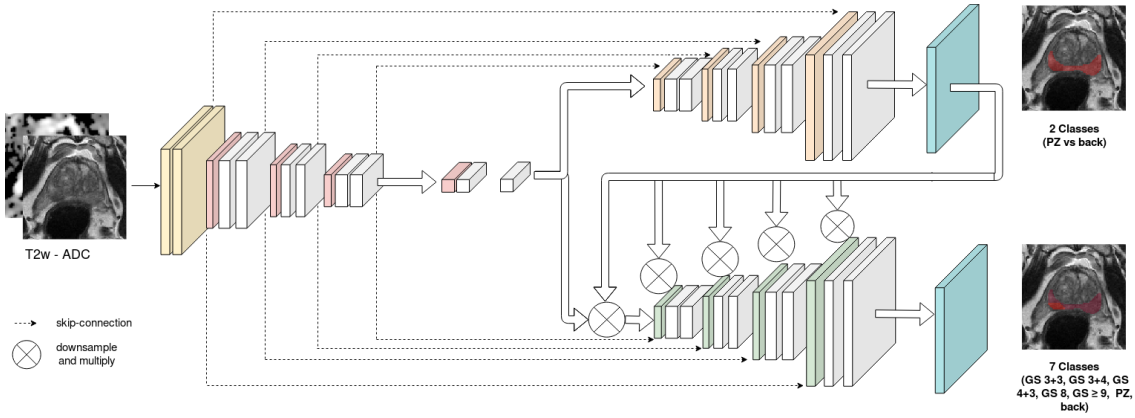

Figure 1: ProstAttention-Net [1]: a novel end-to-end multi-class attention network to jointly perform prostate segmentation and cancer lesions detection with Gleason score (cancer aggressiveness) grading. After encoding the information on a latent space, the network is separated in two branches: 1) the first branch performs PZ segmentation 2) the second branch uses this zonal prior as an attention gate for the detection and grading of PZ lesions.

Machine Learning (ML) has emerged as a field of **artificial intelligence** (AI) that develop inference models of complex phenomena based on learning samples. Application of ML to healthcare is among the most challenging ones with the potential to exploit information provided by exponentially growing mass of heterogeneous data (image, semantic information, biological parameters etc..).

Our team has developed strong skills in the design of computer aided diagnosis and detection tools (CAD) for cancer [2, 3, 4, 5, 1] and brain imaging [6, 7, 8] based on the most advanced machine learning techniques. Such systems are designed to assist clinicians in their diagnosis by highlighting abnormal regions in an image.

One current active project concerns the **prototyping of a computer-aided diagnosis system for prostate cancer screening based on multiparametric magnetic resonance imaging (MRI)** [2, 3, 4, 5, 9, 10, 11, 1]. This project has been funded by INCa and ANR research grants. One of the recent model reported on figure 1 is a novel end-to-end multi-class deep attention network that jointly performs prostate segmentation and cancer lesions detection with Gleason score (cancer aggressiveness) grading [1]. Our model is among the first to perform multiclass segmentation and achieves good performance without requiring any prior manual region delineation in clinical practice.

The purpose of this master project is to improve the performance achieved with the current model architecture by exploring two methodological research axes :

- The first research axis is to investigate strategies to learn on weakly or unannotated data. The vast majority of deep models are indeed supervised, meaning that they are trained on a larges series of annotated samples, which is very hard to agregate. Our current 3D multiparametric (mp) MRI database includes 250 patients with annotations of the prostate gland and cancer lesions. This number, however, is likely to be doubled if we include patients with weak annotations, meaning no prostate and/or lesions contours but information of the number and aggressiveness of cancer at the patient level. Our aim is to develop deep architectures allowing to efficiently combine this fully and weakly annotated data. Predictive modeling based on multi-task or self-transfer learning [12] as well as on constrained losses (e.g. on cancer aggressiveness or localisation) [13] will be considered.

- The second research axis is to encode atypical loss functions accounting for correlations between the different cancer classes or *priors* regarding cancer localisations. In the current models based on standard dice and/or cross entropy losses, correlations between the different cancer classes, corresponding here to the different levels of lesion aggressiveness is not accounted for. Our goal is thus to encode such correlations into the loss, to improve classification performance. We may consider to evaluate ordinal encoding as recently implemented by Cao et al [14] for prostate cancer mapping or consider rank ordering loss functions.

  Both research domains on weakly supervised learning and atypical loss functions are very active in the medical image analysis and computer vision communities. The research program will be defined from the review of the state-of-the art bibliography at the beginning of the master project.

  The successful master candidate will have access to a multiparametric MR imaging database shared by our clinician partner (including more than 250 annotated cases and 250 non annotated clinical exams) as well as datasets from challenges such as PROSTATEx-2 (https://www.aapm.org/GrandChallenge/PROSTATEx-2/).

Skills

Candidate should have a background either in machine learning and/or deep learning or image processing as well as good programming skills. Experience with deep learning libraries such as TensorFlow would be apreciated. We are looking for an enthusiastic and autonomous student with strong motivation and interest in multidisciplinary research (image processing and machine learning in a medical context). The candidate will also have strong interaction with a PhD student, Audrey Duran, working on this project.

Applications

Interested applicants are required to send a cover letter, CV and any other relevant documents (reference letter, recent transcripts of marks,...) to: **carole.lartizien@creatis.insa-lyon.fr**

References

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