PHD Proposal-3 years

SPECT reconstruction with deep learning methods

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Scientific context

The approaches based on deep learning are currently the subject of many studies and they are state of the art methods for image processing tasks like segmentation or denoising. Their application to inverse problems and to reconstruction problems like tomography is also very promising. Very few approaches have been proposed for emission imaging whose specificity is to measure data distributed with a Poisson law and with an objective function based on the Kullback-Leibler distance. For SPECT imaging, the counting rates are low and follow a Poison statistics. The forward operator is not well known because of the attenuation in the patient, of the partial volume effects and of the non stationary spatial resolution. The reconstruction and the quantitative measurements are therefore hampered. In this context, application of deep learning approaches seems very appealing.

Goal and tasks

The aim of this PHD is to investigate deep learning for different formulations of the SPECT imaging inverse problem. With the partial knowledge of the direct operator and of the noise on the data, very noisy SPECT images are obtained with a low resolution. In clinical routine, the images are smoothed to reduce the noise. Another approach is to add some regularization prior (Maxim 2018). All these parameters (direct operator, smoothing method and regularization type, regularization parameter) could be determined more precisely with machine learning methods. The first approach considered will be to optimize a reconstruction network trained to map the data and the reconstructed image (Jin 2017). Recently were proposed several deep learning methods aiming to improve the results obtained with classical iterative approach for inverse problems (Adler 2017). They have to be adapted to the inverse problem set by SPECT imaging. We will also use a regularization term based on a trained neural network like in NETT, Network Tikhonov (Li 2017). There exist a few convergence studies for the Gaussian noise case (Li 2017), but very few studies associate the deep learning methods with the EM algorithm which is the classical iterative method to obtain an approximate solution in SPECT imaging. Another goal of the PHD is to determine the radioactive source distribution and the attenuation and/or the response of the SPECT detector with generative networks that put some constraints on the set of the detector response (Asim 2018). Such a priori could be included in iterative schemes based on GAN networks and variational autoencoders. The methods developed will be tested on large simulated data sets obtained with realistic simulations with Matlab and GATE, a software used in the team "Tomographic imaging and radiotherapy" of the CREATIS laboratory. They could be finally tested on real data sets.

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Profile

Education: the candidate must hold a master or an engineering degree in applied mathematics or image processing. Good programming skills are also required.

Language: English required, French optional

Location: Lyon, France

Period: 3 years

Contact

Send CV, a brief statement of interest and transcript of marks, by email to Voichita Maxim: voichita.maxim@insa-lyon.fr , Bruno Sixou: Bruno.sixou@insa-lyon.fr

References

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