PhD Thesis proposal - 2020.

Statistical analysis of medical image textures with deep convolutional neural networks.

Supervision:

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Starting date: Fall 2020.

Application: We are looking for a motivated and talented student who should be graduated from a master in applied mathematics and have

- a solid background in mathematics,
- some experiences in Image processing or Machine learning,
- programming skills (in Python, preferably),
- a good level of English (and if possible French) both oral and written.

Candidature : To apply, please send a CV and a motivation letter to frederic.richard@univ-amu.fr before the 14th of june, 2020.

Description.

Context and goal. This thesis deals with Texture analysis, which is one of the classical problems of Image processing. This problem is currently experiencing a renewed interest with the advances made from 2012 [8] by deep convolutional neural networks in Computer vision [1, 5]. The main objective of the thesis is to develop statistical methodologies for the classification of textures using an approach based on these neural networks. Carried out in collaboration with the hospital of La Timone (Marseille), the thesis also includes a medical aim concerning the management of neurological brain diseases from molecular imaging by Positron Emission Tomography (PET).

Program. In a series of works [14, 12, 10, 11, 13], we have developed texture analysis methods from image modeling by families of intrinsic Gaussian random fields [3, 4]. These methods essentially consist in characterizing the textures by estimating or testing statistically the properties of the fields. They can be interpreted in terms of convolutional neural networks.

This interpretation constitutes the starting point of the thesis. The connection between variographic analysis and neural networks allows the study of networks to be included in a statistical framework. The main objective will be to deploy networks inspired by variographic analysis for the classification of textures.

Part of the thesis will be devoted to the study of statistical distributions of the layers of developed networks. This study could shed statistical light on the choices of network construction and lead to the definition of a priori constraints aimed at reducing the effects of over-fitting.

This statistical approach will also be used for learning networks. We know that learning a deep network, which has many parameters, requires many examples. To allow us to deal with application domains where the databases are not large enough, we will deploy a learning strategy based on realistic images randomly synthesized from random field simulation techniques [2].

Medical application. Molecular brain imaging by PET is now integrated into the management of neurological brain diseases. In particular, it quantifies the cerebral consumption of glucose and is used as a biomarker for Alzheimer's disease. The analysis tools for these images are currently based on quantified analyzes of a PET signal obtained in units of images taken individually and acquired at equilibrium in a single time. Therefore, they do not take into account information on the spatial interactions between voxels at the origin of image texture. One of the challenges of the thesis is to integrate this information to improve the classification of diseases [9, 6, 7].

Références

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