AVIS DE SOUTENANCE D'UNE THESE DE DOCTORAT

Le Doyen de la Faculté des Sciences a le plaisir d'informer le public qu'une soutenance de thèse de Doctorat en

«Mathématiques, Informatique et Applications»

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La Thèse sera présentée par Mme ESSADIK IBTISSAM

Sous le thème :

Automatic cerebral vascular tree bifurcations classification using Artificial Intelligence - From synthetic to angiographic 3D images

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Sujet de thèse :

Automatic cerebral vascular tree bifurcations classification using Artificial Intelligence - From synthetic to angiographic 3D images

Abstract:

Vessel-related diseases are among the most important public health prob lems in the world community. Current advances in medical imaging deliver 3D high-resolution images of vessels, which allow the generation of accu rate geometric models of patient-specific vessels. Image based vessel analysis provides advanced computer aided diagnosis, intervention and monitoring of vascular diseases. Further, it delivers valuable information for computer assisted surgical planning and navigation, both for avoiding damage to vital structures and for using vessels as anatomical landmarks.

In recent years, artificial intelligence (AI) has been applied in many fields to address complex and critical real-world tasks. Machine and deep learn ing represent subfields of AI in which mathematical models are used to map inputs to desired outputs. The application of machine and deep learning methods to medical imaging aims to create robust methods that can assist in disease diagnosis and automate the analysis of medical images to aid in treatment planning. Deep learning methods perform well in image recogni tion, although, medical images present unique challenges. The lack of large amounts of data, image size, and high class imbalance in most datasets make training a machine learning model to recognize a particular pattern that is present on medical images a difficult and challenging task.

Understanding the surprisingly complex brain functions and pathologies requires a comprehensive cerebral vascular atlas. The development of an ac curate atlas of cerebral arteries and veins is a century-old goal in the field of neuroscience and neuropathology. Among the most crucial components in the brain that require a careful diagnosis is Circle of Willis (CoW). The CoW is a ring of vascular arteries, situated at the base of the brain, that connects the left and right anterior circulation with each other and with the posterior one. In addition, it is commonly known as the site of pathologies, especially cerebral aneurysms, which are pathologic dilations of blood vessels.

Comparing the CoW of different subjects requires an efficient mapping of their anatomical correspondance (registration step), which is called anatomi cal labeling. Anatomical labeling is considered as a mapping of an unlabeled image to an atlas, represented by a knowledge base of the images and struc tural variability. Therefore, it is necessary to develop automatic solutions that extract some anatomical features from cerebrovascular bifurcations and predict its anatomical label, using AI approaches, known as atlas based automatic labeling approaches. From the modelling point of view, we have used different AI techniques to analyze 3D cerebral images in order to design an aided-diagnosis tool that can enhance neuroradiologists' diagnosis and save time and effort in classification tasks. Experiments are conducted to identify the major Bifurcations of Interest (BoIs) comprising the anterior part of the cerebral vasculature. In particular, the bifurcations of the CoW represent the main locations where aneurysms occur. In this thesis, we have tested three different image datasets : synthetic vascular images, mice vasculatures and humain brain MRI (Magnetic Resonance Imaging) scans. Our accurate cerebrovascular atlas can provide an important resource and approach for quantitative studies of CoW function and disease.

The importance of preprocessing training data is also highlighted and demonstrated, especially for medical images, which require extensive preparation to improve classifiers' performance. In this thesis, we further illustrate the effects of the appropriate preprocessing methods on the labeling of BoIs.

In the following, we first review several published studies on automatic labeling of BoIs. Then, we present the main pre-processing steps to prepare the images for the training and classification phases. Afterwards, we propose new solutions to solve the problem of BoIs identification in different types of image data.

Key words: Machine Learning, Classification, Bifurcation labeling, Vascular tree, Artery characterization. Dimensionality reduction, 3D clustering