Stage de Master / MSc Internship

Anatomy-guided extraction of the hepatic vascular network from MR images

Supervision and contact

Pr. Bertrand Kerautret, LIRIS (bertrand.kerautret@univ-lyon2.fr)
Dr. Odyssée Merveille, CREATIS (odyssee.merveille@creatis.insa-lyon.fr)

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Duration: 5/6 months.

Motivations

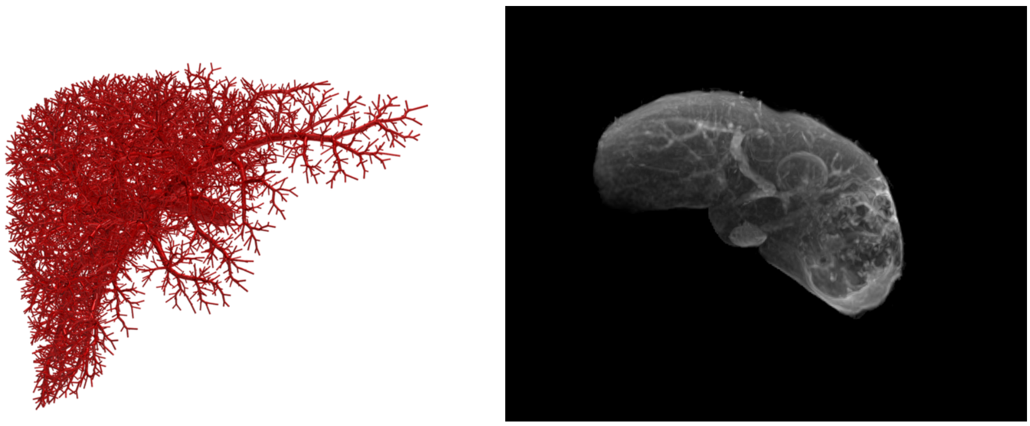
Segmentation of vascular networks from 2D and 3D medical images has been an active research field for the last 20 years. Knowing the morphology, geometry and topology of vascular networks is crucial to help clinicians carry out diagnosis, surgical planning and patient follow up. Notably, a better understanding of lethal liver diseases such as cancer or cirrhosis requires an in-depth study of the hepatic vascular network.

Currently, Computed Tomography (CT) is the routine imaging modality for studying the liver. However, these past few years, Dynamic Contrast-Enhanced Magnetic Resonance Imaging (DCE MRI) has attracted increasing attention in hepatic vascular network investigation [5]. Such imaging modality is non-ionizing, non-invasive, and then safer for the patients than classic injected CT images. However, this comes at the cost of a lower resolution and degraded signal-to-noise ratio. As a consequence, the classical vessel segmentation methods usually fail on such images, in particular in detecting the small distal vessels.

Recent research has proposed vascular models mimicking real vascular networks [8], with a focus on the modeling of those small vessels that are difficult to study from images. In particular, vascular models have been proposed based on mathematical models that mimic correct anatomical, bio-physical and bio- mechanical properties [4]. In this project, we plan to use these models as prior information for hepatic vascular network segmentation.

Content

After a first survey of the recent literature on vascular modeling [8], a potential strategy could consist of considering the *Constrained Constructive Optimization* algorithm [6] which allows one to generate two dimensional vascular trees from biological and physical parameters. In particular, a 3D extension based on the works proposed by Karch et al. [2] and Schwen and Preusser [7] may be considered for taking into account realistic liver parameters, leading to vascular models similar to the one proposed in Figure 1(a).



(a) Example of vascular tree generated from the work proposed Schwen and Preusser [7].

(b) Example of typical image used as input data in our project (maximum intensity projection).

The second part of the project will consist of developing a segmentation approach that will take advantage of information carried by such vascular models. More precisely, the purpose will be to improve the detection of small vessels, that are usually missed by usual methods due to poor signal-to-noise ratio. This may occur, in particular, on MR images such as those considered in this internship.

To this end, several strategies could be considered:

- To develop a measure penalizing unlikely segmented vessels with respect to the vascular model. This measure could be computed based on accumulation/confidence images [3].
- To propose a new strategy inside the generation of the vascular model algorithm by using relevant image information deduced from other types of images.

Depending of the progress of the internship work, a potential extension could be to extend the vascular model in order to simulate realistic MR images. Such type of image generation could be used to train convolutional neural networks to get new segmentation results.

Skills

Mandatory: programming (C++ and/or Python), image analysis and processing.
Appreciated: medical imaging, experience with the DGtal Library [1].

Location

The candidate will be hosted at the LIRIS laboratory or at the CREATIS laboratory, both located in Lyon.

Application and deadlines

To apply, the candidate need to contact us by email: `bertrand.kerautret@univ-lyon2.fr` and `odyssee.merveille@creatis.insa-lyon.fr`.

References

[1] DGtal: Digital Geometry tools and algorithms library. `http://dgtal.org`.

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