Sujet de Thèse / PhD position

Feature-based interactive segmentation of the hepatic vascular network from 3D MR images

Supervision and contact

Advisors	Pr. Bertrand Kerautret	Pr. Nicolas Passat (co-advisor)
Address	LIRIS, Bâtiment C, 5 avenue Pierre Mendes France 69676 Bron France	CReSTIC, UFR Sciences Exactes et Naturelles, Moulin de la Housse, 51867 Reims
Email	bertrand.kerautret@univ-lyon2.fr	nicolas.passat@univ-reims.fr
Office	C 119, LIRIS, Bron	CReSTIC, Reims

Keywords

3D segmentation, medical applications, vascular network

Location

The candidate will be hosted at the LIRIS laboratory, in the Imagine team (Bron).

Application and deadlines

To apply, the candidate need to fill the form on this website: http://rvesselx.iut-auvergne.com/phd1. Submission site will close on **15 November 2018** and candidature selection awaited around mid of December (PhD start for mid of February).

Subject

Segmentation of vascular networks from 2D and 3D (bio)medical images has been an active research field during the last 20 years. Indeed, important information can be obtained from vascular morphology, geometry and topology, that can help clinician to carry out diagnosis, plan surgical intervention, follow up patients. In this context, one of the most studied organs is the liver, and the main associated imaging modality has been CT (X-ray Computed Tomography). For a couple of years, dynamic contrast-enhanced magnetic resonance imaging (DCE MRI) is gaining an increasing role in hepatic vascular network investigation [9]. The purpose of this PhD thesis is to propose new image analysis methods and tools for allowing the clinician end-users to efficiently analyze such data.

Vascular extraction from CT liver image based on vessel enhancement and skeletonization [9].

More precisely, the purpose of this research work will be twofold. On the one hand, the first challenge will consist of determining vascular features within images. In other words, a local analysis of the image will aim at determining information about the probability of presence of a vessel [12], its putative size and orientation [10], its topological coherence [7], etc. Such features will be used as a complementary, high-level information allowing one to enrich the basic information intrinsically carried by the MR signal. To reach that goal, we will build upon gold standard vesselness operators and recent advances in the field of low-level angiographic image analysis, for building novel, efficient vessel-characterization operators.

On the other hand, we will investigate how various hierarchical image models [15] may be used for developing interactive, feature-based segmentation tools devoted to extract the hepatic networks, but also to allow for their incremental, real-time and user-friendly refinement and correction [11]. In particular, recent advances in morphological hierarchies will provide us with a relevant framework for investigating strategies based on both multiscale analysis [6] of vascular structures (from large, proximal vessels to fine, distal ones) and topological correction of networks (based in path operators and oriented connectedness [14] for vessel

reconnection [5]). Other strategy could be explored and combined from the accumulation/confidence based approach for which implementation are proposed [8].

Building upon a long and successful academic/industrial experience [1, 2], this PhD work will be carried out in the context of the R-Vessel-X project, funded by the French *Agence Nationale de la Recherche*. It will take place at LIRIS, Université Lyon 2, and will also induce strong interactions with Kitware SAS (Lyon), with the purpose of finally providing ITK open-source software tools (see e.g. [13] for related, previous works). Other complementary interactions will be encouraged from the development of the DGTal library [3] and its companion project [4].

Skills

Mandatory: programming (C++ and/or Python), image analysis and processing.
Appreciated: medical imaging, experience with the DGtal Library [3].

References

[1] ANR project – MAIA. http://recherche.imt-atlantique.fr/maia.

[2] ANR project – VIVABRAIN. http://icube-vivabrain.unistra.fr/index.php/Presentation.

[3] DGtal: Digital Geometry tools and algorithms library. http://libdgtal.org.

[4] DGtalTools: Tools associated with dgtal library. https://github.com/DGtal-team/DGtalTools.

[5] Dufour, A., Tankyevych, O., Naegel, B., Talbot, H., Ronse, C., Baruthio, J., Dokládal, P., and Passat, N. Filtering and segmentation of 3D angiographic data: Advances based on mathematical morphology. *Medical image analysis 17*, 2 (2013), 147–164.

[6] Frangi, A. F., Niessen, W. J., Vincken, K. L., and Viergever, M. A. Multiscale vessel enhancement filtering. In *International Conference on Medical Image Computing and Computer-Assisted Intervention* (1998), Springer, pp. 130–137.

[7] Kerautret, B., Krähenbühl, A., Debled-Rennesson, I., and Lachaud, J.-O. Centerline detection on partial mesh scans by confidence vote in accumulation map. In *2016 23rd International Conference on Pattern Recognition (ICPR)* (2016), pp. 1376–1381.

[8] Kerautret, B., Krähenbühl, A., Debled-Rennesson, I., and Lachaud, J.-O. On the Implementation of Centerline Extraction based on Confidence Vote in Accumulation Map. In *Proceedings of the First Workshop of Reproducible Research in Pattern Recognition* (2016), B. Kerautret, M. Colom, and P. Monasse, Eds., vol. 10214, Springer, pp. 109–123.

[9] Lèbre, M.-A., Vacavant, A., Grand-Brochier, M., Merveille, O., Chabrot, P., Abergel, A., and Magnin, B. Automatic 3-D Skeleton-Based Segmentation of Liver Vessels from MRI and CT for Couinaud Representation. In *ICIP 2018*, pp. 3523–3527.

[10] Merveille, O., Talbot, H., Najman, L., and Passat, N. Curvilinear structure analysis by ranking the orientation responses of path operators. *IEEE Transactions on Pattern Analysis and Machine Intelligence 40*, 2 (2018), 304–317.

[11] Naegel, B., and Passat, N. Interactive segmentation based on component-trees. *Image Processing On Line 4* (2014), 89–97.

[12] Passat, N., Ronse, C., Baruthio, J., Armspach, J.-P., and Maillot, C. Magnetic resonance angiography: From anatomical knowledge modeling to vessel segmentation. *Medical image analysis 10*, 2 (2006), 259–274.

[13] Passat, N., Salmon, S., Armspach, J., Naegel, B., Prud'homme, C., Talbot, H., Fortin, A., Garnotel, S., Merveille, O., Miraucourt, O., Tarabay, R., Chabannes, V., Dufour, A., Jezierska, A., Balédent, O., Durand, E., Najman, L., Szopos, M., Ancel, A., Baruthio, J., Delbany, M., Fall, S., Pagé, G., Génevaux, O., Ismail, M., de Sousa, P. L., Thiriet, M., and Jomier, J. From real MRA to virtual MRA: Towards an open-source framework. In *International Conference on Medical Image Computing and Computer-Assisted Intervention* (2016), Springer, pp. 335–343.

[14] Perret, B., Cousty, J., Tankyevych, O., Talbot, H., and Passat, N. Directed connected operators: Asymmetric hierarchies for image filtering and segmentation. *IEEE Transactions on Pattern Analysis and Machine Intelligence 37*, 6 (2015), 1162–1176.

[15] Salembier, P. J., Oliveras Vergés, A., and Garrido, L. Antiextensive connected operators for image and sequence processing. *IEEE Transactions on Image Processing 7*, 4 (1998), 555–570.