

## Ph.D. research topic

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- Title of the proposed topic: **Automatic segmentation of the vascular system to enhance AI-based decision support system for peripheral artery disease**

- Research axis of the 3iA: AI for integrative computational medicine (axis 2)

- **Supervisor (name, affiliation, email):**

Juliette RAFFORT-LAREYRE (CHU NICE/ UNIVERSITE COTE D'AZUR)

raffort-lareyre.j@chu-nice.fr

- Potential co-supervisor (name, affiliation):

Maria A. ZULUAGA (EURECOM)

maria.zuluaga@eurecom.fr

- The laboratory and/or research group:

Université Côte d'Azur, Data Science Department, EURECOM

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**Apply by sending an email directly to the supervisor.**

**The application will include :**

- Letter of recommendation of the supervisor indicated above
  - Curriculum vitæ.
  - Motivation Letter.
  - Academic transcripts of a master's degree(s) or equivalent.
  - At least, one letter of recommendation.
  - Internship report, if possible.
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- Description of the topic:

Cardiovascular diseases are the leading cause of premature death in developed countries (1). Among them, peripheral artery disease (PAD) affects more than 230 million people worldwide (2, 3). The disease is caused by the narrowing (stenosis) or the obstruction (thrombosis) of the arteries that vascularize the lower limbs due to the formation of plaques related to atherosclerosis (2, 3). The diagnosis relies on the combination of clinical examination, functional assessment and identification of arterial lesions on imaging (4). Several imaging techniques are available and computed tomography angiography (CTA) is one of the most commonly used (2, 3).

PAD is a major public health concern as the disease is highly prevalent and is associated with high rates of morbidity and mortality (2, 3). Despite the elevated risks of cardiovascular mortality and amputation, PAD remains underdiagnosed and underestimated (5). It is often diagnosed at an advanced stage of the disease due to low patient awareness and high prevalence of asymptomatic disease or atypical symptoms (6). In addition, several studies have suggested

that many patients may be undertreated, pointing to the need to improve the use of evidence-based recommended therapies in patients with PAD (7).

Our group develops AI applications for patients with vascular diseases including PAD, mainly focusing on enhancing automatic segmentation of the vascular system. Our previous work has provided a method based on expert system and supervised deep learning to enable automatic segmentation of the aorta and associated aneurysm on CTA images (8, 9).

The aim of this project is to create an automatic method for the segmentation of the arteries of the lower limbs based on CTA and to develop an aid-decision support to enhance evidence-based decision and precision medicine for patients with PAD. The main tools developed will include:

- automatic detection and identification of the main arteries of the lower limbs,
- diagnosis of diseased arteries and quantification of the severity of the arterial occlusion,
- automatic calculation of scannographic scores grading the severity of the disease,
- investigation of clinical and anatomical patterns predictive of the outcomes of patients using machine learning.

Close collaboration between clinical partners (University Hospital of Nice and Hospital of Antibes Juan-les-Pins) and technical team (EURECOM) will enhance the development of the platform in a dynamic environment and will allow feedback from users.

## References:

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2. Song P, Rudan D, Zhu Y, Fowkes FJI, Rahimi K, Fowkes FGR, et al. Global, regional, and national prevalence and risk factors for peripheral artery disease in 2015: an updated systematic review and analysis. *Lancet Glob Health*. 2019;7(8):e1020-e30.
3. Kullo IJ, Rooke TW. CLINICAL PRACTICE. Peripheral Artery Disease. *N Engl J Med*. 2016;374(9):861-71.
4. Aboyans V, Ricco JB, Bartelink MEL, Bjorck M, Brodmann M, Cohnert T, et al. Editor's Choice - 2017 ESC Guidelines on the Diagnosis and Treatment of Peripheral Arterial Diseases, in collaboration with the European Society for Vascular Surgery (ESVS). *Eur J Vasc Endovasc Surg*. 2018;55(3):305-68.
5. Criqui MH, Aboyans V. Epidemiology of peripheral artery disease. *Circ Res*. 2015;116(9):1509-26.
6. McDermott MM. Lower extremity manifestations of peripheral artery disease: the pathophysiologic and functional implications of leg ischemia. *Circ Res*. 2015;116(9):1540-50.
7. Lee DW, Cavender MA. Guidelines for Peripheral Vascular Disease: Where Is the Evidence? *Circ Cardiovasc Interv*. 2019;12(1):e007561.
8. Lareyre F, Adam C, Carrier M, Dommerc C, Mialhe C, Raffort J. A fully automated pipeline for mining abdominal aortic aneurysm using image segmentation. *Sci Rep*. 2019;9(1):13750.
9. Lareyre F, Adam C, Carrier M, Raffort J. Automated Segmentation of the Human Abdominal Vascular System Using a Hybrid Approach Combining Expert System and Supervised Deep Learning. *J Clin Med*. 2021;10(15).