

Kinematic analysis and modeling of a multimodal system for the acquisition of triple-imaging modality data (PET/CT/US).

Professional domain: In vivo Imaging / Computer Science

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State of the art & rationale:

PETRUS was the first implementation of simultaneous multimodal analysis to explore the topographic relationship between tumour vascularization and metabolism using simultaneously co-registered Positron Emission Tomography (PET) with Ultrafast Ultrasound Imaging (UII) examinations in animal models [1, 2]. After the first results revealing the potential of the multimodal visualization [2], the system is ready to begin its transition to the clinical practice. Recently, the feasibility of the technique at a bigger scale has been assessed and a general registration pipeline and modeling is required for its first application under clinical conditions.

Methods and tools:

The selected candidate will be in charge of the optimization of the registration pipeline by the exploration of marker-less and unsupervised registration techniques including the optimization of the transducer trajectory during the examination using advanced robotics.

Role of the student / Main tasks:

- MONTH 1-2: Optimization of a marker-based approach for registration and exploration of registration techniques.
- MONTH 3: Design and analysis of the kinematic model for the imaging system.
- MONTH 4-6: AI based marker-less registration and optimal scan trajectory selection.

REQUIRED SKILLS:

- ULTRASONIC IMAGING: Ultrafast ultrasonic imaging, MATLAB.
- COMPUTER SCIENCE: Computer vision, multimodal registration, CNN
- (DESIRED) ROBOTICS: Inverse and forward robot kinematics, structural analysis and simulation.

Anticipated outcomes and potentials:

- An automatic markerless registration pipeline to simultaneously coregister PET/CT/US modalities using a clinical US and CT/PET scanner.
- Image/Vision guided trajectory prediction algorithm based on the geometrical and kinematic properties of the imaging system.

References:

- [1] Provost, Jean, et al. "Simultaneous positron emission tomography and ultrafast ultrasound for hybrid molecular, anatomical and functional imaging." *Nature biomedical engineering* 2.2 (2018): 85-94.
- [2] Perez-Liva M, Viel T, Yoganathan T, et al. Performance evaluation of the PET component of a hybrid PET/CT-ultrafast ultrasound imaging instrument. *Physics in Medicine & Biology*. 2018; 63: 19NT01.
- [3] Facchin, Caterina, et al. "Concurrent imaging of vascularization and metabolism in a mouse model of paraganglioma under anti-angiogenic treatment." *Theranostics* 10.8 (2020): 3518.
- [4] Perez-Liva M, Yoganathan T, Herraiz JL, et al. Ultrafast Ultrasound Imaging for Super-Resolution Preclinical Cardiac PET. *Molecular Imaging and Biology* 22 (2020):1342