Simulation study for spectral X-ray computed tomography: Application to heart diseases

Heart diseases remain one of the most serious health problems and the leading cause of death in most regions around the world. Despite decades of fundamental and clinical researches, customised treatment of heart diseases is still a major challenge. The bottleneck is to be able to quantify the drug efficiency, which is known to be patient-dependent. To tackle this problem, an imaging modality able to visualise the spatial distribution of drugs inside the organ or tissue is essential.

The PhD thesis aims to investigate a novel imaging modality, spectral X-ray Computed Tomography (CT) combined with the use of specific contrast agents in order to find new approaches to the diagnosis, monitoring and treatment of heart diseases. To this end, the work consists in simulating different physical situations, evaluating the detectability of different contrast agents, investigating the algorithms of image processing and reconstruction, and optimising the whole for heart diseases application.

The work will be based on a simulation tool ("Virtual X-ray Imaging") developed by our laboratory and an experimental bench to carry out feasibility studies. Then, the validation will be done on the first machine in the world for spectral CT which will be installed in Lyon in the frame of the France Life Imaging platform.

The present study is proposed and will be supervised by two laboratories, LVA (Philippe Duvauchelle & Valérie Kaftandjian), and CREATIS (Yue Min Zhu) and will be realised in strong collaboration with Cardio Hospital of Lyon (Pr Philippe Douek and Loïc Boussel).

More details on the INSA Institute and LVA laboratory

INSA Lyon is one of the major universities of Science and Technology in Europe. Created in 1957, INSA Lyon trains yearly more than 900 multi-competent engineers over a 5 year curriculum and has 23 research laboratories. Research involves more than 500 professors and assistant professors, as well as about 600 PhD students. Topics may be civil engineering, chemistry, biology, informatics, telecommunications, mechanics…

The Laboratoire Vibrations Acoustique (LVA) counts 5 professors, 11 assistant professors, 1 engineer, 1 technician, 2 secretaries, 10 PhD students, 3 post doctoral researchers. LVA is a partner of the laboratory of excellence CeLyA, the Institut Carnot I@L, the research group GDR Visible. Its research activity contributes to the four main research fields:

- acoustic radiation (measurement, prediction of noise radiation and sound insulation, for single and multi-layered panels) and mid-frequency prediction (improvement of statistical methods, substructuring of complex systems);
- source identification (reconstruction of forces transmitted to a structure from measurements using inverse methods);
- sound and vibration perception (tools for improvement of sound quality, interaction of sound and vibration);
- diagnostics, surveillance, and non-destructive testing (unified multi-scale wave-based approach to Health Monitoring of machines, structures, components, and materials).

During the last 4-years period, this work lead to the publication of 55 papers in international peer reviewed journals (mainly Acta Acustica united with Acustica, Journal of the Acoustical Society of America, Journal of Sound and Vibration, Mechanical Systems and Signal Processing, Applied Acoustics) and more than 100 communications in international congresses. The lab. was recently given an A+ mark (the best evaluation) by the French Agency for Research Evaluation (Aeres).LVA is currently a partner of the European funded "Mid-Frequency project" and participated to several previous projects (Silence, Norma, Visper…). It was one of the eight European laboratories involved in the Marie Curie EDSVS program (European Doctorate for Sound and Vibration Studies). Some other projects are supported by the French State (Environmental and Energy Saving Agency) and the county (Rhône-Alpes). Finally, many studies are conducted with an industrial support (car or plane manufacturers or suppliers, household appliances…).