PhD thesis – "Hierarchical integration of cardiac imaging data with machine learning."

Context: Cardiac diseases directly impact cardiac mechanics and lead to a decrease in the pumping performance. Standard imaging protocols include measurements on static and dynamics images in different views to examine both the myocardial wall and the cardiac chambers. For example, an echocardiographic examination [WHA-15] (the most routine imaging in cardiology) includes B-mode 2D sequences in parasternal long-axis, short-axis, and apical 2-3-4 chamber views, and Doppler sequences for hemodynamics, but are often complemented by finer acquisitions in 2D, 3D, or during stress to quantify more advanced aspects of the cardiac function [MOR-11]. Similar considerations apply to magnetic resonance acquisitions, which can include dynamic cine sequences and labeled (contoured) late-enhancement images for the visualization of myocardial damage, and less routine acquisitions for extracting wall motion such as tagging or dense imaging.

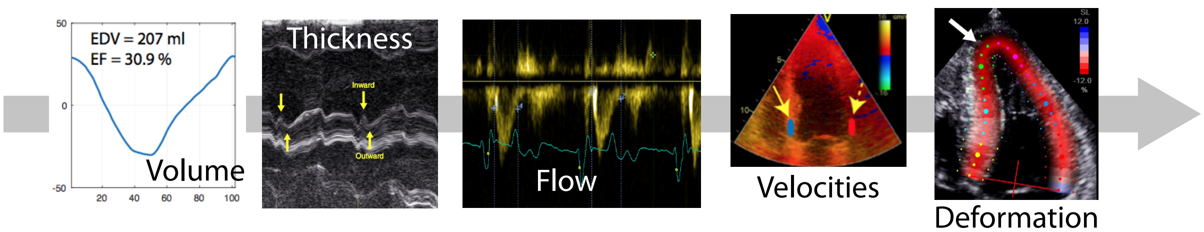

Figure: Example of descriptors of increasing complexity from a 2D echocardiographic protocol.

Objectives: We would like to better consider the amount of data collected in routine imaging protocols, which is currently under-exploited in computer-based methods, through **statistical analysis and machine learning** techniques that represent disease traits within a population. As the data descriptors are **complex, high dimensional, and of heterogeneous types**, this integration is challenging. We have developed a way to mix multiple descriptors at the same time within the framework of manifold learning, which has interesting statistical properties to compare subjects [SAN-17], but does not question at all the potential redundancy or increasing complexity of the input descriptors.
The proposed PhD therefore aims at designing a new methodology for the **integration of high-dimensional imaging descriptors according to a given hierarchy**, and taking care of its efficiency and robustness to handle large databases. Applicative aspects will be of prime importance, to interact with clinicians around the input data, the data hierarchy, and the use of the data representation for better understanding cardiac diseases.

Profile: We look for a highly motivated candidate, with:

- MSc in data science and/or machine learning and/or applied mathematics
- Motivated by the clinical application
- Good programming skills (MATLAB, Python, or C/C++)
- Fluent in English (reading, writing, speaking)

Practical information:

- The PhD is part of the **ANR JCJC project MIC-MAC** (2019-2022, PI: N. Duchateau), which focuses on new strategies to model hierarchy between cardiac descriptors with machine learning.
- The PhD will take place at **CREATIS Lyon**, reference French lab in medical imaging, which consists of ~160 people grouped in 5 research teams. It will be supervised by N. Duchateau (Associate Professor) and P. Clarysse (Research Director) within the team "Modeling and Imaging of Vessels, Thorax and Brain".
- Duration: **3 years, starting end 2019**.

Contact: Send your CV, motivation letter, references, and grades to: nicolas.duchateau@creatis.insa-lyon.fr

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References:

[MOR-11] Mor-Avi V, Lang RM, Badano LP, et al. Current and evolving echocardiographic techniques for the quantitative evaluation of cardiac mechanics. *Eur J Echocardiogr*. 2011;12:167-205.

[SAN-17] Sanchez-Martinez S, Duchateau N, Erdei T, et al. Characterization of myocardial motion patterns by unsupervised multiple kernel learning. *Med Image Anal*. 2017;35:70-82.

[WHA-15] Wharton G, Steeds R, Allen J, et al. A minimum dataset for a standard adult transthoracic echocardiogram: a guideline protocol from the British Society of Echocardiography. *Echo Res Pract.* 2015;2:G9-24.