MSIAM 2 Internship proposal **2019-2020**

Machine Learning of Blood Flow

Chaouqi Misbah / Emmanuel Maitre / Valérie Perrier
LiPhy (Laboratoire Interdisciplinaire de Physique) and **LJK** (Laboratoire Jean Kuntzmann)

Context Cardiovascular dysfunctions are the world's leading cause of mortality. Blood flow involve Red Blood Cells (RBCs), the major cellular component, and a complex fluid/interaction problem. Simulation and identification of key features of blood flow would improve our understanding of the pathophysiology of the vascular diseases that occur in a blood flow-dependent manner and contribute to the development of new treatments. Direct numerical simulation of blood flow for a realistic vascular network, which involves thousands/millions of RBCs, is however quite prohibitive. LiPhy researchers developed during past years several numerical codes to which access will be provided for this internship.

Subject The goal of the project is to enpower direct numerical simulations by machine learning strategies. The idea is to train a neural network on a short time scale simulation *dt* (with the direct simulations codes already available), from a current shape of RBC to the output shape. This training will be performed on a large number of computer-built library of initial shapes (described by a limited number of parameter) and orientations for a given RBC. The output will be the parameters describing the shape of RBC after evolution by *dt*. Once this neural network built, the aim is to compare its use as a black box evolver over a *dt* time step to compute the future dynamics of the RBC, on a long time horizon.

Landmarks
– get acquainted to numerical model and code developed in LiPhy.
– build the library from this code, in a database.
– build a neural network and pre-train it on a standard image dataset.
– train the neural network on the built database.
– compute the evolution of a RBC on a larger time scale and compare with direct numerical simulation
– consider the case of several RBCs and more complicated geometries.

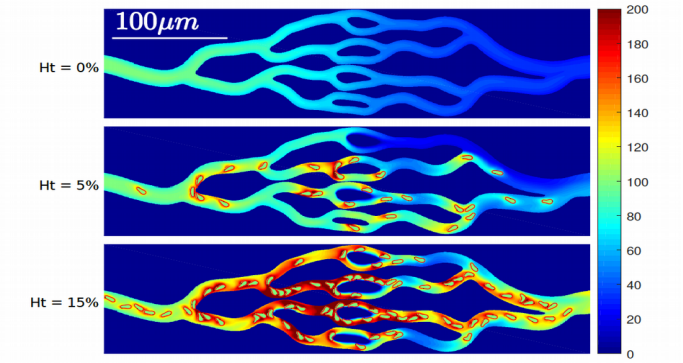

Figure 1: Simulation of blood flow and ATP transport in a Netwrok extracted from medical images. Closed red contours are red blood cells, and the color code refers to ATP release; Ht refers to hematocrit