Analysis and modelling of the dynamics of pathogen-host interactions through force microscopy and image-based mechanobiology

Résumé du projet de recherche (Langue 1)

The aim of this thesis is to propose methods that are based on 3D imaging data to measure and quantify biological forces in a non-invasive and non-direct manner and to develop an integrated and robust framework to relate imaging data to physical quantities. To this end, we will take a data assimilation approach that combines image processing functionals that describe deformations within images (i.e. registration problems such as optical flow) with physical models that explain the observed deformations and whose parameters are to be measured (e.g. biological forces). This approach has been formulated previously in our laboratory as a Bayesian PDE-constrained inverse problem. This thesis will develop further the previous method in two main directions: 1. Extend its application from linear to viscoelastic models that better reflect the polymeric nature of biological materials. This will require accounting for non-linearities, for instance combining the Finite Element Method with Newton’s method; and dealing with time-dependent domains, for example via arbitrary Lagrangian-Eulerian methods; and 2. Develop mathematical strategies that allow regularising the Bayesian inverse problem with edge-preserving priors, which are typically non-linear and thus too computationally expensive to implement under the current PDE-constrained framework. We will apply this general method to study the mechanobiology underlying two kinds of host-pathogen interactions.