Universitat Pompeu Fabra Barcelona | Master in Bioinformatics for Health Sciences

Master project 2024-2025

Personal Information

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Group	Systems Biomedicine

Project

Computational systems biology

Project Title:

Digital twins of organoids by multi-scale modeling

Keywords:

Multimodal data integration, digital twins, organoids, network science, representation learning

Summary:

Organoids and, more broadly, 3D cellular models, are considered as one of the most significant advancements in modern science due to their ability to precisely recreate tissue and organ structures, model diseases, allow perturbation screenings, and overall serve as viable alternatives to animal models. However, these in vitro models remain heterogeneous, complex, and costly to develop, thereby constraining their optimal utilization. This project aims to develop a digital twin model for organoids. We will infer intra- and inter-cellular regulatory networks from diverse (single-cell, multi, spatial) omics data, and further integrate them in a multi-scale digital twin through advanced techniques like agent-based modeling. The digital twin can then be used to simulate the effects of perturbations induced by mutations or drugs.

References:

● Ponce-de-Leon, Miguel, Arnau Montagud, Vincent Noël, Annika Meert, Gerard Pradas, Emmanuel Barillot, Laurence Calzone, and Alfonso Valencia. 2023. "PhysiBoSS 2.0: A Sustainable Integration of Stochastic Boolean and Agent-Based Modeling Frameworks." Npj Systems Biology and Applications 9 (1): 54. ● Argiro L, Chevalier C, Choquet C, Nandkishore N, Ghata A, Baudot A, et al. "Cardiopharyngeal Mesoderm specification into cardiac and skeletal muscle lineages in gastruloids." bioRxiv; 2023. [A collaborative effort to analyze time-series single cell dataset of an embryonic organoid]

Expected skills:

analytical and computational skills, (omics) data analyis

Possibility of funding:

Yes

Possible continuity with PhD:

To be discussed

Comments:

Systems Biomedicine team is located in La Timone medical Campus in Marseille, France. The team fosters close collaboration with

Elisabeth Remy and her team in the Mathematics institute. Remote/hybrid work to be discussed. Fellowships available for international students. Recent publications from the lab: ● Cantini L, Zakeri P, Hernandez C, Naldi A, Thieffry D, Remy E, Baudot A. "Benchmarking joint multi-omics dimensionality reduction approaches for the study of cancer." Nature Communications. 2021 Dec. An extensive benchmark of multi-omics data integration approaches, demonstrating our expertise in leverage data from different sources to better understand the molecular mechanisms of diseases. ● Baptista A, Gonzalez A, Baudot A. "Universal multilayer network exploration by random walk with restart." Commun Phys. 2022 Jul 1;5(1):1–9. The implementation of an innovative network algorithm able to explore and extract information from heterogeneous network sources.