Ph.D. Student (f/m/d): Data-Driven Simulations of Tissue Dynamics in Developing Embryos

The Center for Advanced Systems Understanding (CASUS) is a German-Polish research center for data-intensive digital systems research. We combine innovative methods from mathematics, theoretical systems research, simulations, data science, artificial intelligence, and computer science to provide solutions for a range of disciplines – materials science under ambient and extreme conditions, earth system research, systems biology and medicine, and autonomous vehicles.

CASUS was jointly founded in August 2019 by the Helmholtz-Zentrum Dresden-Rossendorf (HZDR), the Helmholtz Centre for Environmental Research (UFZ), the Max Planck Institute of Molecular Cell Biology and Genetics (MPI-CBG), the Technical University of Dresden (TUD) and the University of Wroclaw (UWr). CASUS is located in the heart of Görlitz at the border between Germany and Poland. The CASUS start-up phase is hosted by the Helmholtz-Zentrum Dresden-Rossendorf and is financed by the Federal Ministry of Education and Research (BMBF) and the Saxon State Ministry for Higher Education, Research and the Arts (SMWK).

The CASUS Department of Systems Biology is looking for a PhD Student excited about **physics-based computational approaches to understanding living systems**. Consideration of candidates will begin immediately and will continue until the position is filled. Location of work is Görlitz, remuneration is according to the German Civil Service Tariff and HZDR employment conditions. No tuition charged.

The Scope of Your Job

CASUS's Systems Biology Department, in partnership with the Center for Systems Biology Dresden and the Federal Cluster of Excellence "Physics of Life" at TU Dresden, seek to understand living matter on the basis of physical principles. A physical principle that has been particularly successful in describing the behavior of active biological material out of equilibrium is the theory of Active Polar Gels. Traditionally, this theory is used in a top-down way starting from the conservation laws expressed as partial differential equations. While this was successful, it begs the question what the values and molecular meanings of the coefficients in the equations are. In this project, we address this fundamental question in a data-driven way. We exploit recent advances in learning mathematical models from data (https://arxiv.org/abs/1907.07810) in order to use microscopy videos of developing embryos to learn bottom-up physical models. These data-driven model will include the chemical regulation and the biomechanics of the tissue in an attempt to explain the self-organized emergence of shape and function during morphogenesis. Comparing these models with the top-down derived models will provide new insight into the mysterious physics of life.

Your Tasks

- Develop a machine-learning framework to learn spatiotemporal models from microscopy videos
- Investigate the possibility of directly learning on the raw video data, combining computer vision and model inference in to one step
- Interface with the other CASUS Departments in order to explore the use of Physics-Informed Neural Networks, as they are used in plasma physics, for biological applications
- Implement scalable versions of the method as open-source code
- Learn data-driven models of tissue development in embryos of zebrafish and fruit fly
- Compare the models to the existing physical theories and conclude novel effects from the differences
- Publish your results in academic, peer-reviewed journals
- Present your results at scientific meetings

Your Qualifications

- Master's degree in Computational Biology, Applied Mathematics, or Computational Physics
- A solid background in biology, in particular developmental biology and cell biology
- Excellent Programming skills in Python or C++
- Experience in computational statistics, inference, and machine learning
- Experience in video and image processing or computer vision
- Strong motivation to work in a collaborative and interdisciplinary environment
- Excellent communication skills in English and in a professional context (presentation of research results at scientific meetings, colloquial discussions, writing of manuscripts).

What We Offer

- A vibrant research community in an open, diverse, and international work environment
- Scientific excellence and high quality of training according to the Helmholtz Doctoral Guidelines
- Broad national and international science networks
- Cutting-edge, professionally managed high-performance computing resources
- Scientific computing and software engineering support team
- Salary according to the German Collective Wage Agreement for the Civil Service (TVöD)
- Comprehensive benefits package (30 vacation days per year, company pension plan (VBL), flexible working hours, in-house health management, relocation assistance).

Please submit your application (including a one-page cover letter, CV, academic degrees, transcripts, etc.) online on the HZDR application portal:

https://www.hzdr.de/db/Cms?pNid=490&pOid=61507

Deadline:

Rolling application – open until filled.

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