Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Department of Biosystems Science and Engineering

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D-BSSE
Department of Biosystems Science and Engineering

The Control Theory and Systems Biology group (http://www.bsse.ethz.ch/ctsb) of the Department of Biosystems Science and Engineering (D-BSSE), ETH Zürich in Basel, is seeking for a

MSc student

for **the theoretical development of in-silico control methods for the control of heterogeneous cell populations** as part of a master thesis.

In-silico control of cell populations have been shown to be a promising way for overcoming the inherent difficulties of implementing in-vivo controllers using synthetic biology tools. A major advantage is the availability of the computational power of computers allowing us to implement very complex controller structures. Several control methods have been developed, notably those based on optogenetics [1] and microfluidic devices [2] coupled with integral or predictive controllers. When dealing with a population of heterogeneous and stochastically behaving cells, one is mostly interested in controlling the average quantity of some protein of interest over the cell population (variance control can also be of interest). Unfortunately, working with moments is often difficult because of the so-called “moment closure problem”, meaning that first-order moments depend on the second-order ones, the second-order ones on the third-order ones, etc., thereby resulting in a non-closed system of differential equations. While this is usually a problem when one wants to simulate the moments equations or analyze them, things become, however, easier when it comes to control them. In such a setup, higher-order moments can indeed be measured from the real process and used as inputs to the controller (higher-order moments can be interpreted here as measured disturbances).

The project will be devoted to the identification of the class of controllers that can achieve (robust) closed-loop stability and (robust) output-tracking for such systems. The classes of networks for which such controllers exist will also be needed to be characterized. The obtained results will be validated by numerical simulations using realistic models.

The prospective student should have prior experience in dynamical systems and control theory. Prior knowledge on systems biology would be an advantage, but is not necessary. The student should be able to work independently but proper support will be provided.

Note: candidates living in Zürich are also highly encouraged to apply. Presence in Basel may only be necessary for one or two days per week.

Contacts:

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References :

[1] A. Milias-Argeitis, S. Summers, J. Stewart-Ornstein, I. Zuleta, D. Pincus, H. El-Samad, M. Khammash, and J. Lygeros. In silico feedback for in vivo regulation of a gene expression circuit. Nature Biotechnology.

[2] J. Uhlendorf, A. Miermont, T. Delaveau, G. Charvin, F. Fages, S. Bottani, G. Batt, S. Bottani, G. Batt, and P. Hersen. Long-term model predictive control of gene expression at the population and single-cell levels. PNAS.