Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Department of Biosystems Science and Engineering

ETH Zürich
WRO-1058.7.14
Mattenstrasse 26
CH-4058 Basel

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 insulation methods in synthetic biology** as part of a master thesis.

Modularity is an essential concept in engineering (electrical eng., hydraulic eng., mechanical eng., computer science) ensuring that complex systems can be built upon smaller parts by simply assembling them together. Unfortunately, modularity does not naturally hold in synthetic biology and achieving modularity still remains an elusive task, principally due to the so-called “loading effect”. Assume indeed, for instance, that we would be interested to induce oscillations in some protein concentrations. Having a modular framework would mean that we simply have to connect an oscillator to the input of the gene expression network corresponding to the protein of interest in order to get oscillations in the protein concentrations. However, in practice, the gene expression network will act as a load on the oscillator module, thereby inducing a retroaction which may eventually destroy the oscillatory behavior of the oscillator [1]. Inspired from electrical engineering ideas, an insulator consisting of fast chemical reactions allowed the designers to insulate a source from the load [2]. A theoretical analysis of the behavior of this insulator has been carried out in the deterministic setting, a framework that is only valid when the number of molecules involved in the networks is large. Unfortunately, this assumption may not be satisfied in biological systems as certain molecular species can be present in very low abundance. When this happens, stochastic models have been proven to be suitable tools for representing the dynamics of chemical reaction networks.

The first part of the project will be devoted to the development of a relevant concept for insulation in a stochastic setting (which does not exist yet). Several different insulation scenarios can be tackled, depending on whether the source and/or the insulator are stochastic. The second part of the project will be devoted to the derivation of insulation modules, their analysis and their simulation. A possible third phase could be devoted to the development of other potentially useful modules.

The prospective student should have prior experience in dynamical systems. Prior knowledge on stochastic models for systems biology, synthetic biology or electrical engineering 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:

Dr. Corentin Briat (inquiries) corentin.briat@bsse.ethz.ch
Prof. Dr. Mustafa Khammash (applications) mustafa.khammash@bsse.ethz.ch

References :

[1] P. Jiang, A. C. Ventura, E. D. Sontag, S. D. Merajver, A. J. Ninfa, and D. Del Vecchio. Load-induced modulation of signal transduction networks. Science Signaling.
[2] D. Del Vecchio. Modularity in signaling systems. Physical Biology.