Steering cellular phenotypes using modelling and feedback control

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Abstract:

The ability to program and design *ad hoc* cellular and biological processes offers exciting opportunities in basic research, in the biotechnology industry and in the clinic.
Difficulties in engineering cellular phenotypes robust to changes and perturbations, as well as the lack of established tools to design biological functions across scales, still represent major roadblocks.

In this talk I will start discussing our recent research that leverages feedback control to engineer robust cellular phenotypes. I will show results obtained using intracellular, external or multicellular controllers in both bacterial and mammalian cells, and new applications of cybergenetics methodologies we are currently exploring (e.g., control-based analysis of gene networks' dynamics, combination therapy design).

I will also mention a complementary approach aimed at rational and computer-aided cell design via whole-cell models (WCMs), which are mathematical models designed to capture the function of all genes and multiscale processes within a cell. The design of minimal bacterial genomes will be used as a proof-of-concept; I will also show how machine learning can support WCMs' output interpretation and solve their computational burden challenge.

Our tools and results should make the design and control of complex cellular phenotypes and laboratory engineering a step closer.