Control of bio-digital circuits in single cells

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Abstract

Akin to the developments in industry, also in scientific wet labs more and more manual tasks are being automated and many experiments are nowadays carried out by computer controlled robots. Such experiments are, however, still almost exclusively pre-planned by the scientist as a series of exact instructions that are to be carried out by the robot. Industry, on the other hand, has seen developments such as self-driving cars where the user specifies a goal and the system decides for itself how to best attain that goal. In this talk, I will present our recent efforts to construct autonomous bio-digital circuits that are based on real-time computer-to-single cell communication. In particular, I will present an experimental/technological platform in which cells, equipped with an optically inducible gene, signal to a computer through microscopy. The computer processes the incoming data in real time and sends back light signals to the cells. Experiments on this platform can therefore be specified as algorithms that map the received data from all the cells into a list of light signals. To demonstrate that our platform enables novel types of experiments, I will show how we used it to (i) perform parallelized real-time control of gene expression in hundreds of individual bacteria, (ii) control cell-cell variation during antibiotic perturbations, (iii) implement hybrid bio-digital circuits in single cells with freely-specifiable virtual communication between individual bacteria. These examples showcase how the integration of theoretical models and algorithms with measurement and control of many individual cells enables us to investigate and engineer biochemical processes in completely new ways.

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