Control System-Based Reverse Engineering of Circadian Oscillators

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Control systems are a concept from engineering to achieve a desired dynamical behaviour like adjusting temperature. Later, they came into the scope of life sciences as part of a cybernetic approach to understand biological systems. The control system-based description of the circadian clock found in *New Zealand Weta* can be seen as pioneering example [LC83]. Control systems benefit from a strict modularisation that allows a clear decomposition of a complex system into functional units interconnected by signalling channels. Signal processing is commonly represented by block diagrams that map input or memorised signals into output signals. Its correspondence to modular functional units and dedicated reaction network motifs was shown in [WSW+05]. Within an ongoing study, we combine the specification of block diagrams with the ability to an *artificial evolution* of reaction network candidates exhibiting a desired input/output interdependency. Here, dynamical behaviour analysis enables selection of the fittest candidates. In this way, each component of a control system (e.g. controller, actuator, plant, sensor) can be independently reconstructed by providing numerous, topologically different network candidates. Finally, the arrangement of these candidates leads to valid models of the entire system. By means of this modular network evolution, the search space is significantly reduced while keeping a high probability of heuristical success. With the SBMLevolver [LHID07], a suitable software to this task is available. We obtained building blocks with non-linear transmission behaviour to be composed towards distinct circadian control systems at various levels of description.

References

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