Synchronisation of clocks: Comparing mechanisms in biological and technical distributed systems

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Exploration of chronobiological systems emerges as a growing research field within bioinformatics focusing on various applications in medicine, agriculture, and material sciences. From a systems biological perspective, the question arises whether biological control systems for regulation of oscillative signals and their technical counterparts [TvS01] utilise similar mechanisms. If so, modelling approaches and parameterisation adopted from building blocks can help to identify general components for clock synchronisation. Phase-locked loops could be an interesting candidate in this context [Ste97]. Both, biology and engineering, can benefit from a unified view. We analyse a model of coupled repressilators [EL00, Kur84]. Within two case studies, we exemplify internal synchronisation in a monofrequential manner by a biological system composed of bidirectionally coupled repressilators entirely ODE-based modelled using appropriate reaction kinetics. The first study discloses the time to synchronisation subject to initial phase shift between the elementary repressilators. Its balanced diffusion rate acts as coupling strength. It appears that synchronisation of initially antiphasic signals is most time-consuming for weak coupling while it has a negligible effect for strong coupling. A second study investigates the synchronisation behaviour with respect to different initial frequencies of the elementary repressilators. The obtained results are envisioned to identify building blocks and their parameterisation towards composition of a control system following the concept of phase-locked loops.

References

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