論文の内容の要旨

A Mathematical Approach to Treating Diseases

(疾患の治療への数理的アプローチ)

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Mathematical models are very useful tools for understanding the essence of many phenomena in the field of medicine and biology. In this thesis, we consider mathematical approaches to the treatment of disease. We mainly focus on three topics. The first is the construction of a prediction method from short observations of bio-markers. Our method is an extension of an existing online machine learning theory. We show that our method employs proper mathematical theories and that numerical simulations explain the observational data. In the past decade, mathematical models of prostate cancer have been constructed that exhibit a good accuracy in describing the dynamics of bio-markers. We combine a model of prostate cancer with our method, and show that we can predict the time-series of the bio-marker appropriately. The second topic concerns an analysis of the robustness of networks composed of biological oscillators. This is motivated by regenerative medicine. We show how effectively the oscillatory activities recover in damaged oscillator networks. The third topic considers multi-layered oscillator networks and analyzes their dynamical robustness. This work is related to the robustness of biological networks in which damage would cause disease. We reveal that an increase in the mismatch of damaged portions among the layers makes the multi-layer networks fragile. Our studies in this thesis provide a framework for predicting the time-series of bio-markers and an insight into dealing with regenerating systems. These results not only give beneficial tools for practical applications, but also contribute to the progress of applied mathematics.