

【Grant-in-Aid for Scientific Research (S)】
Integrated Disciplines (Informatics)



**Title of Project : Establishing Theoretical Foundations for
Mathematical Modeling of Pathological Biosystems
and its Applications to Personalized Medicine**

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Research Project Number : 15H05707 Researcher Number : 40167218

Research Area : Informatics

Keyword : Mathematical system theory, Complex systems, Biological information

【Purpose and Background of the Research】

Since spatio-temporal big data are recently available in the field of biological and life sciences, mathematical informatics researches on how to analyze such data are becoming important more and more. In particular, our research aims at developing mathematical modeling of pathological biosystems and its applications to personalized medicine. By this project, we will establish theoretical foundations for personalized medicine that can be widely used in real practice.

【Research Methods】

For studies of complex systems, it is useful to mathematically derive and analyse their models. Thus, we will develop methods of such mathematical modeling and analysis by focusing mainly on hormone therapy for prostate cancer and the Dynamical Network Biomarkers (DNB) theory, a new concept for biomarkers. By analysing physiological big data of various diseases and validating these methods, we will construct mathematical theory with real applicability for realizing personalized medicine (Fig. 1).

【Expected Research Achievements and Scientific Significance】

(1) Hormone Therapy Based on Mathematical Models for Prostate Cancer and its Expansion to Other Diseases

We will explore possibility of personalized medicine by using tailor-made mathematical models constructed with clinically observed time series data of biomarkers such as prostate specific antigen (PSA). Our mathematical methods, especially based on short time series data in clinics, will enable to judge which is more appropriate, continuous or intermittent androgen suppression (IAS), and schedule IAS optimally for each patient when IAS is chosen. Deciding optimal treatment schedules can be also made possible for various other diseases that will acquire treatment resistance.

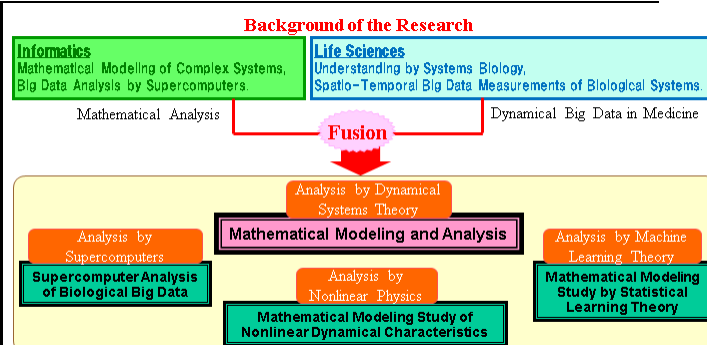


Figure 1 Summary of this research.

(2) Dynamical Network Biomarkers Theory:
Developments and its Applications

DNBs aim at identifying the critical pre-disease state between healthy and disease states, rather than distinguishing healthy and disease states. Thus, this research characterizes the state transitions from healthy to disease attractors. We will enable to diagnose and start treating various diseases at their very early stages near but before the bifurcation points leading to disease states.

【Publications Relevant to the Project】

- [L. Chen, R. Liu, Z.-P. Liu, M. Li, and K. Aihara: "Detecting Early-warning Signals for Sudden Deterioration of Complex Diseases by Dynamical Network Biomarkers," Scientific Reports, Vol.2, Article No.342, pp.1-8 \(2012\).](#)
- [Y. Hirata, N. Bruchovsky, and K. Aihara: "Development of a Mathematical Model that Predicts the Outcome of Hormone Therapy for Prostate Cancer," Journal of Theoretical Biology, Vol.264, No.2, pp.517-527 \(2010\).](#)

【Term of Project】 FY2015-2019

【Budget Allocation】 148,000 Thousand Yen

【Homepage Address and Other Contact Information】

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