

Simplicity and Complexity

- Unified Governing Function for Complex Systems -



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Abstract

Unique characteristics of a complex system are; 1) a large number of interacting elements are self-organized to form a non-linear dynamic system, and 2) the emerging properties of a complex system are not directly related to the interacting elements. A quantitative input-output transfer function is in need to rationally direct the complex system to the desired optimal state.

In the case of therapy, the interacting components are drug molecules and disease-causing elements. The emerging properties are efficacy and/or toxicity. A cascade of sub-complex-systems, such as cells, tissues, and organs, spans nine orders of magnitude in length scales to link biomolecules to the human body. Hence, it will be very challenging, if not impossible, to derive a quantitative system governing law by taking the reductionist-based bottom-up approach.

By taking an inductive approach based on experimental evidence and small-data artificial neural networks analysis of the test data, we discovered that the phenotypic response surface (PRS) to the combinatorial drug stimulations is a simple smooth surface, which can be represented by a simple non-linear dynamic function. The PRS function links the emerging property, phenotypic response, to the drugs interacting with the entire body system.

The PRS function is mechanism-independent and hence indication agnostic. We have varied the function in more than 30 different disease models. The small-data AI-based PRS platform enables us to dynamically optimize the combinatorial regimen of a specific patient. We have successfully demonstrated personalized medicine in prospective clinical trials of cancers, organ transplants, and infectious diseases.

Optimization of mechanical properties in physical complex systems, e.g., material synthesis or manufacturing process, involves searches in a very large space. In fact, physical complex systems are also governed by the PRS functions. G.B. West has found many metrics, e.g., wages, and crime rate, of urban areas follow the universal scaling law. We re-processed West's data and found that the PRS function can also work in social complex systems. The PRS function seems to be a unified governing function for complex systems in general.

Biography

Dr. Chih-Ming Ho received his B.S. from Mechanical Engineering Department of National Taiwan University and Ph.D. from Mechanics and Material Sciences Department of The Johns Hopkins University. He is the UCLA Ben Rich-Lockheed Martin Professor Emeritus. He served as UCLA Associate Vice Chancellor for Research from 2001 to 2005.

He is among the pioneers of AI-personalized medicine, micro/nanofluidics, and control of turbulence. He was ranked by ISI as one of the top 250 most cited researchers in all engineering categories (2001-2014). In 1997, Dr. Ho was inducted as a member of the US National Academy of Engineering. In the next year, he was elected as an Academician of Academia Sinica. He has received a Doctor of Engineering Honoris Causa from the Hong Kong University of Science and Technology and holds ten honorary professorships globally. Dr. Ho was elected as Fellow of AAAS, APS, AIMBE, AIAA and 3M-Nano Society.

Time: 10:00-11:30 on Aug. 12(Fri), 2022. Place: Engineering Building 1- R107
Host: Prof. Da -Jeng Yao (djyao@mx.nthu.edu.tw)