Research Proposal

Some reasons prompt to focus my attention on nonlinear dynamic and information processing in neural system.

Most of natural objects and phenomena surround us are comprised by dynamic system and can be described by nonlinear equations, such as capacitor, population evolution, especially the neural systems. But even simple nonlinear dynamical systems often exhibit almost random, completely unpredictable behavior—chaos. I am interested by the fundamental results of the development of dynamic system theory, which are formulated to deal with those objects related somehow they worked. I’m also fascinating by the information processing mechanism in neural systems. Chaos theory can do well on them, so I choose my proposed research work on chaos and nonlinear neural dynamic system.

At the turn of this century, I took up a research assistant position in the Bio-X laboratory. My mentor the renowned scientist and fellow of the Chinese Academy of Sciences, Prof. TANG Xiaowei led me into the field: Neuroinformatics. I embarked on a joint project on Nonlinear Dynamic Modeling of Olfaction cooperated with Prof. Water J. Freeman of UC Berkeley. The complex Freeman’s K model is a neural network with remarkable pattern recognition abilities and thus is utilized to classify simple objects. I found it great fun to program in MATLAB and to mold the theoretical model into a useful application. Due to the chaotic nature of the neural system, the research involved advanced mathematics in nonlinear dynamics. I was highly motivated to delve into different disciplines, including nonlinear dynamics, chaos, and numerical analysis. This project is the main part of my Bachelor and Master degree thesis.

Three years ago, On the report seminar of Prof. ZHENG Bo who is Chang-Jiang (distinguished) professor and my Advanced Statistical Physics lecturer, I proposed my idea of using the scaling theory, a nonlinear dynamic method who used in financial data analysis, on electroencephalogram (EEG), then I cooperated with him on this project. Now there is a group on Zhejiang Institute for Modern Physics (ZIMP) working on this project and all is on schedule. During the cooperation with Prof. Zheng, I proposed another project -- Using Persistent Changing Probability for analysis of nucleotide sequences, I think it will go deeply.
In the latest two years, I spend a lot of time working on the project of *Building a New Nonlinear Dynamic model Used on Olfactory Neural System*, which is cooperated with Prof. TONG Qingye. I would like it to be my proposed research works. We get the nonlinear dynamic differential equation -- Hodgkin-Huxley equation first, and use it to simulate the main type of cells in mammalian olfactory system in order to get the neural spiking series. Then we use the method of *Circle Map* to map the data series to trajectory domain. After analysis the bifurcation behavior, we use the method of *Symbolic Dynamics* in circle map to sort the series we get. Through comparing with those series between different stimulation or different network connection, we can take out information from neuron spikes. What’s more, the group of Prof. Tong has solved many problems on *Symbolic Dynamics* in circle map, such as the weak signal measurement using chaotic electric circuit. The aim of this project is simulate olfactory neural system, in order to find the mechanism of how the animal can detect weak signals even a few odorant molecular. I think even a little advancement can lead us to know more about the mysteries neural system or brain system, and the result can be used to make measurement equipment.

My research focus would preferably on *Nonlinear Dynamic model on Olfactory Neural System* which I described in the last paragraph, I’m glad to do researches on some related fields on chaos and biophysics such as coupled map lattice, control and synchronization of chaos, protein aggregation and crystallization etc.

With my enthusiasm, analytical ability and solid background on interdisciplinary science, I entertain no doubt of my academic capacity in all its energy.

Yours truly,

GUO Hongji

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