Name：Risa Uechi

Title：Boston University, Center for Polymer Studies, Department of Physics

Institute: Bioinformatics Center (Akutsu Laboratory), Kyoto University Institute for Chemical Research; Kyoto, Uji, Gokasho 611-0011, Japan

Partner institute: Random Matrix Theory and its application for complex phenomena

Duration: April 4, 2013 – July 1, 2013

Report:

Overview

Owing to the support of ITP program, I had a chance to visit Boston University as a visiting scholar during April 4th to July 1th, 2013. I stayed at the laboratory of H. Eugene Stanley, who is the William Fairfield Warren Distinguished Professor, Professor of Physics, Professor of Biomedical Engineering and Professor of Physiology (School of Medicine), Center for Polymer studies, Department of Physics, Boston University. The office was located at 590 commonwealth avenue, which is close to Kenmore square. The group of Gene Stanley is very large and there are a lot of visiting students, visiting Professor at any time from any country. Gene Stanley's group have contributed not only physiology and medicine fields but many research fields such as statistical physics and neuroscience (Alzheimer's Disease), econophysics, social science, social networks, percolation theory and phase transition phenomena in water molecule. They also collaborate actively with Albert-László Barabási who is the Professor of Northeastern University and contributed complex phenomena using Power law model. The Gene Stanley's group and Albert-László Barabási group have joint seminar at Northeastern University twice in a month. During the stay at BU, there were Ph. D. defense of Ph. D. students in Gene Stanley's group and every student supported. Professor Shlomo Havlin, who is a Professor in the Department of Physics at Barllan University, discuss the topic of network system with graduate students. I mainly worked with Dr. Dror Kenett, who is the post doctor of Gene Stanley's group. We analyze the complex system such as social interaction, biological networks, stock market regulation using Random Matrix Theory and its correlation. I have learned a lot from

him and other faculties and they gave me useful comments for applying statistical method and concepts for complex phenomena.

Research Project

1. Random Matrix Theory

Random Matrix Theory (RMT) is a statistical tool to evaluate eigenvalues that deviate from the range of the random ones assuming null hypothesis. RMT is developed in the field of nuclear physics by Wigner, Dirac in order to explain the energy levels of complex quantum systems. Its primary aim is to analyse large dimensional data sets. The RMT is widely applied not only in physics but also image analysis, genomics, epidemiology and economics. If we get the empirical correlation matrix C which is constructed from the time series data, which is constructed from the small changes of time, the correlation between i and j is described as follows

$$C_{ij} = \frac{1}{T}\sum_{t=1}^{T}\delta x_i(t)\delta x_j(t)$$

We can describe (2.1) as $\boldsymbol{C} = 1/T\boldsymbol{M}\boldsymbol{M}_T$, where $\boldsymbol{M}$ is a $N \times T$ rectangular matrix. If _ is the density of eigenvalues of $\boldsymbol{C}$, ρ is defined as

$$\rho(\lambda) = \frac{1}{N}\frac{dn(\lambda)}{d\lambda},$$

where n is the number of eigenvalues of $\boldsymbol{C}$ less than _. If $\boldsymbol{M}$ is a $T \times N$ random matrix, has

self-similarity and known in the limit that $n \to \infty$, $T \to \infty$, and $Q = T{=}n \geq 1$

$$\rho(\lambda) = \frac{Q}{2\pi\sigma^2}\frac{\sqrt{(\lambda_{max}-\lambda)(\lambda_{min}-\lambda)}}{\lambda}.$$

The distribution is bounded by

$$\lambda_{max} = \sigma^2\left(1+\frac{1}{Q}+2\sqrt{\frac{1}{Q}}\right),$$
$$\lambda_{min} = \sigma^2\left(1+\frac{1}{Q}-2\sqrt{\frac{1}{Q}}\right).$$

2. Partial Correlation Metrics

Empirical correlation matrices are of great importance in data analysis in order to extract the underlying information contained in experimental signals and time series. In addition to the direct measure of correlation, various classes of statistical tools, such as principal component analysis, singular value decomposition and factor analysis, strongly rely on the validity of the correlation matrix in order to obtain the meaningful part of signal from experiments. Partial correlation is a tool to assess how the correlation between two variables depends on the correlation of each of the variable with a mediating variable. The partial correlation between variable i and j , using index m as the mediating variable is defined as follow

$$\rho(i, j|m) = \frac{C(i, j) - C(i, m)C(j, m)}{\sqrt{(1 - C^2(i, m))(1 - C^2(j, m))}},$$

where $C(i; j)$ is the pairwise correlation between variable i and j, $C(i;m)$ is the pairwise correlation between stock i and the index m, and $C(j;m)$ is the pairwise correlation between variable j and the index. We examined the deviated number of eigenvalue. Deviations from the random matrix case might then suggest the presence of true information. We found that the eigenvalue with partial correlation contained more information than other correlation matrices using RMT.

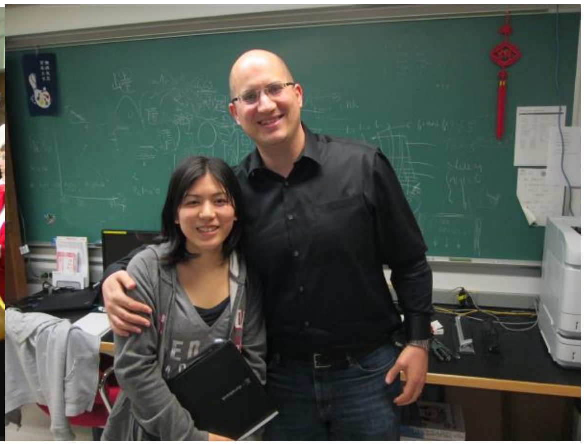
<u>Others</u>

Other side of research activities, I visited some historical places in Boston. Boston has a lot of historical places in which U.S. history has begun and famous author of American literature had lived in Boston.

CONCORD MUSEUM (Concord)

THE HOUSE OF SEVEN GABLES (Salme)

With colleague at Japanese festival



With Dr. Kenett at office