Flow improvement caused by agents who ignore traffic rules

Seung Ki Baek 1, Petter Minnhagen 1, Sebastian Bernhardsson 1, Kweon Choi 2, Beom Jun Kim 3

1. Department of Physics, Umeå University, Umeå, Sweden
2. Gyeonggi Science High School, Suwon, Korea
3. Department of Physics, Sungkyunkwan University, Suwon, Korea

A system of agents moving along a road in both directions is studied within a cellular-automata formulation. An agent steps to the right with probability $q$ or to the left with $1 - q$ when encountering others. Our model is restricted to two agent types, traffic-rule abiders ($q = 1$) and igners ($q = 1/2$). The traffic flow is obtained as a function of density and relative fraction of the agent types. The risk for jamming at a fixed density, if starting from a disordered situation, is smaller when all the agents abide by the rule than when all ignore it. Nevertheless, the minimum occurs when a small fraction of igners are present within a majority of abiders. Characteristic spatial patterns are obtained and discussed.
Performance of strategy evaluation schemes for different price patterns

Yongjoo Baek¹, Sang Hoon Lee¹, Hawoong Jeong¹,²

¹. Department of Physics, Korea Advanced Institute of Science and Technology, Daejeon, Korea
². Institute for the BioCentury, Korea Advanced Institute of Science and Technology, Daejeon, Korea

We observe the performances of three strategy evaluation schemes, which are the history-dependent wealth game, the trend-opposing minority game, and the trend-following majority game in a stock market where the price is exogenously determined. The price is either directly adopted from the real stock market indices or generated with the Markov chain of order ≤ 2. The wealth game, as it learns from the history, shows relatively good performance unless the market is highly unpredictable. The majority game and the minority game are suitable for a market where their expectations are fulfilled. These observations suggest under which market circumstances each evaluation scheme is appropriate for modeling the behavior of real market traders.
Stock market volatility: An approach based on the concept of entropy

Sonia R. Bentes¹ and Rui Menezes²

¹ISCAL, Lisboa Portugal, www.iscal.ipl.pt, smbentes@iscal.ipl.pt
²ISCTE, Lisboa, Portugal, www.iscte.pt, rui.menezes@iscte.pt

One of the major issues studied in finance that had always intrigued, both scholars and practitioners, and to which there were not yet discovered a unified theory, is the reason why prices move over time and their underlying volatility, which actually seems to affect markets as a whole. Since there are several well known traditional techniques in the literature to measure stock market volatility, a central point in this debate that constitutes the actual scope of this paper, is to put together this common approach in which we discuss popular techniques like the variance and/or standard deviation, and an innovative methodology based on Econophysics which applies concepts of physics to explain economic/financial phenomena. In this particular study, we use the concepts of Shannon entropy, Renyi entropy and Tsallis entropy to capture the nature of volatility. More precisely, what we want to know in our study is if entropy is able to detect volatility in stock market indexes and to compare its values with the ones obtained from the variance and/or standard deviation analysis. For our purpose, we shall basically focus on the behaviour of seven stock market indexes: TSX 60 (Canada), CAC 40 (France), DAX 30 (Germany), MIB 30 (Italy) NIKKEI 225 (Japan), FTSE 100 (UK) and S&P 500 (USA) for a comparative analysis between the approaches mentioned above. The results are however mixed.
Impact of interaction structures on priority-queue network dynamics

Won-kuk Cho, Byungjoon Min, K.-I. Goh, and I.-M. Kim

Department of Physics, Korea University, Seoul, Korea

Human activity patterns have been recently shown to follow heavy-tailed distributions. The priority-based queueing system has been proposed as a framework to treat that, and the dynamics of binary interacting priority-queue model was studied. We extend the study of the waiting time dynamics for priority-queue networks considering various forms of human interaction. The waiting time distributions exhibit power-law behaviours, with different exponents depending on specific interaction rules. Especially, the pairwise interactions seem to be essential dynamic consequences of the interactions in the priority-queue network dynamics. We also find out that the reciprocity of influence is relevant factor for the priority-queue network dynamics.
Long-memory covariance and correlation matrices and their use in finance

David Morton de Lachapelle\textsuperscript{1,2}, Olivier Lèvèque\textsuperscript{2}, Matteo Marsili\textsuperscript{3}

1. Swissquote Bank, Gland (Geneva Office), Switzerland
2. Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland
3. Abdus Salam International Center for Theoretical Physics, Trieste, Italy

Weighted covariance and correlation matrices exploit the time-clustering of events to improve the quality of forecasters used for financial risk assessment and portfolio allocation. The underlying idea is to put more weight on recent events, as the latter are better predictors of the near future than events that occurred far in the past. As recently shown by econophysicists, standard weighted estimators using exponentially decreasing profiles rapidly lead to ill-conditioned matrices as the dimensionality of the estimator (i.e. the number of assets) increases. In part to overcome this issue, we introduce a new class of weighted covariance and correlation matrices $C$ with adjustable long-memory profiles. Extending a famous result of Random Matrix Theory by Marčenko and Pastur, we show how to preserve the conditioning and spectral noise band of $C$, while at the same time taking advantage of the clustered dynamics of the volatility for better covariance forecasts. We apply our results to improve Markowitz's well-known Mean-Variance Optimization scheme.
Order-parameter flows in stochastic processes of quantum information processing

Jun-ichi Inoue

Hokkaido University, Sapporo, Japan

In terms of the stochastic process of quantum-mechanical version of Markov chain Monte Carlo method, we analytically derive macroscopically deterministic flow equations of order parameters such as spontaneous magnetization in infinite-range ($d(=\infty)$)-dimensional quantum spin systems. By means of the Trotter decomposition, we consider the transition probability of glauber-type dynamics of microscopic states for the corresponding ($d+1$)-dimensional classical system. Under the static approximation, differential equations with respect to macroscopic order parameters are explicitly obtained from the Master equation that describes the microscopic-law. In the steady state, we show that the equations are identical to the saddle point equations for the equilibrium state of the same system. The equation for the dynamical Ising model is recovered in the classical limit. We also check the validity of the static approximation by making use of computer simulations for finite size systems and discuss several possible extensions of our approach to disordered spin systems for statistical-mechanical informatics. Especially, we shall use our procedure to evaluate the decoding process of Bayesian image restoration. With the assistance of the concept of dynamical replica theory, we derive the zero-temperature flow equation of image restoration measure showing some ‘non-monotonic’ behaviour in its time evolution. Other possible applications of our procedure to information retrieval process in the presence of quantum fluctuation such as memory recalling process of quantum-mechanical version of the Hopfield model will be discussed.
Dynamics of pedestrians: crowds and individuals

Asja Jelić ¹, C. Appert-Rolland ¹, S. Caussé ², P. Degond ³, S. Donikian ⁴, J. Fehrenbach ³, J. Hua ³, S. Lemercier ⁴, M. Masmoudi ³, M. Moreau ², M. Moussaid ², L. Navoret ³, J. Pettré ⁴, G. Theraulaz ²

1. Laboratoire de Physique Théorique, Université Paris-Sud XI, Orsay, France
2. CRCA, Université Paul Sabatier, Toulouse, France
3. IMT, Université Paul Sabatier, Toulouse, France
4. Bunraku - IRISA / INRIA, Rennes, France

Human crowds and pedestrian groups exhibit complex and coordinated spatio-temporal patterns such as the spontaneous spatial organization of pedestrian flows into lines, and the oscillations of fluxes at gates or intersections. Despite their importance, these phenomena are not well understood, in particular the ‘microscopic’ interactions between the individuals and with their environment which govern the macroscopic behavior at medium and high densities.

In the frame of a collective project implying four French laboratories (LPT in Orsay, CRCA and IMT in Toulouse, BUNRAKU in Rennes), we have started an experimental and theoretical study of the formation of spatio-temporal structures within moving pedestrians crowds. We shall present the first results from the experimental campaign of 2009. Our aim is to better understand the role of the various (physical and behavioral) parameters which control and modulate these structures in controlled laboratory conditions, and to develop realistic analytical and simulation models of crowds based on these experimental data.
Consistent Community Identification in Large Scale Networks

Daniel Kim¹, Jinyoung You², Haewoon Kwak², Sue Moon², and Hawoong Jeong¹

1. Department of Physics, KAIST, Daejeon, Korea
2. Computer Science department, KAIST, Daejeon, Korea

Various algorithms based on diverse measures have been suggested for mining communities in networks. Only a few of them, however, can be practically used for large scale networks and nevertheless suffer from inconsistent outcomes. We observe that approximately 40% of nodes in two social networking sites, Orkut and Cyworld with heterogeneous community size distributions, are grouped into communities in inconsistent ways in contrast to the results of other data by using our iterative reinforcing method. To find out the cause of the inconsistency, we applied our method to all the possible connected graphs up to the number of 9 nodes. We also obtain "modularity landscape" of all the possible community partitions in a specific 8 nodes network to see how our reinforcing method quantitatively advances. Finally, we compare our method with a modularity-free hierarchical link clustering method and discuss its validity and limitation.
The effect of the underlying topology on the synchronization of discrete-event simulation

Jung Hwa Kim ¹, Soonhyung Yook ², Yup Kim ³

1. Department of Physics, Kyung Hee University, Seoul, Korea
2. Department of Physics, Kyung Hee University, Seoul, Korea
3. Department of Physics, Kyung Hee University, Seoul, Korea

The parallel discrete-event simulation scheme is known to be closely related to the interface roughening phenomena. In this study, we investigate the Sneppen model without quenched noise on small-world networks. The Sneppen model without quenched noise belongs to Kadar-Parisi-Zhang universality class. To investigate the effect of underlying topology on the roughening phenomena of the model, we use small-world networks generated by adding shortcuts between randomly selected sites in one-dimensional lattice. From Monte Carlo simulations, we find that the growth exponent, $\beta$, crossovers from $1/3$ to $1$ and the roughness exponent, $\alpha$, approaches to $1$, when the number of shortcuts are finite. By measuring the height-height correlation function, we show that the shortcuts do a role of defects which cause such a nontrivial behavior.
Exploring the temporal correlation structure of a singular return

Gyuchang Lim, Soo Yong Kim, Kyungsik Kim

1. Department of Physics, Korea Advanced Institute of Science and Technology, Daejeon 305-701, South Korea
2. Department of Physics, Pukyong National University, Busan 608-737, Korea

In this work, we construct a cross-correlation matrix from a set of time series segments, which are obtained by applying the moving window method to a singular time series. We assume that each segment represents the state of a system because fluctuations are closely related to the state of a system. As the volatility clustering is a well-known stylized fact for a financial market, it is in fact described that a certain pattern of fluctuations can be repeated regularly or irregularly. From these facts and assumptions, we find the group of segments which are statistically close to each other in terms of correlation coefficients. Particularly, since we give an appropriate probability measure to each group, we simulate the future returns not from a statistical model or a complex random walk process, but from empirically obtained returns.
The Survival, Persistence, and Correlation in a Stock Market

Doo Hwan Kim ¹, Moon-Yong Cha ¹, and Jae Woo Lee ¹

1. Department of Physics, Inha University, Incheon, Korea

We consider the survival, persistence, and the price-price correlation function in a Korean stock market. The survival probability, \( S(t) \), measures the probability of a stock's index remaining above (or below) a reference value up to a time interval \( t \). We observed the survival probability followed a power law, \( S(t) \propto t^{-\beta} \), where the exponent \( \beta \) depends on the reference level. The persisting time defined a time interval when the index remains above (or below) an initial index. The persistence probability also followed a power law, \( P(t) \propto t^{-\theta} \), with the persistent exponent \( \theta = 0.477(2) \). We investigated the price-price correlation function, \( F_q(t) \). The price-price correlation function followed a power law, \( F_q(t) \propto t^{h(q)} \), where \( h(q) \) is the generalized Hurst exponent. We observed a relation \( \theta + h(2) = 1 \) within error bar.
Cascading failure model of world economy system

Kyu-Min Lee¹, Jae-Suk Yang², Gunn Kim³, Jaesung Lee⁴, Kwang-il Goh¹, In-mook Kim¹

1. Department of Physics, Korea University, Seoul, Korea
2. Columbia Business School, Columbia University, New York, NY, USA
3. Department of Physics, Kyung Hee University, Seoul, Korea
4. Department of Mathematics, Sogang University, Seoul, Korea

In recent years, global economic crisis has become more important matter. In addition, this globalized crisis spreading shows emergent collective dynamics due to the interdependence between countries. From this point of view, here we study a cascading failure model on top of a network of countries based on trading relations. We examine the individual country’s role in the crisis spreading and how it is affected by trade network structure. We also discuss implications of our results for the prospect of the ongoing globalization.
Global dynamic routing for scale-free networks

Xiang Ling¹, Mao-Bin Hu¹, Rui Jiang¹, Yong-Hong Wu² and Qing-Song Wu¹

1. School of Engineering Science, University of Science and Technology of China, Hefei 230026, People's Republic of China
2. Department of Mathematics and Statistics, Curtin University of Technology, Perth WA 6845, Australia

Traffic is essential for many dynamic processes on networks. The efficient routing strategy [Phys. Rev. E 73, 046108 (2006)] can reach a very high capacity of more than ten times of that with shortest path strategy. In this paper, we propose a global dynamic routing strategy for network systems based on the information of the queue length of nodes. Under this routing strategy, the traffic capacity is further improved. With time delay of updating node queue lengths and the corresponding paths, the system capacity remains constant, while the travel time for packets increases.
Scaling and memory of volume volatility and return intervals

Wei Li, Fengzhong Wang, Shlomo Havlin, and H. Eugene Stanley

1. Center for Polymer Studies and Department of Physics, Boston University, Boston, MA 02215 USA
2. Minerva Center and Department of Physics, Bar-Ilan University, Ramat-Gan 52900, Israel

We study the daily trading volume volatility of 17197 stocks in the U.S. stock markets for period 1989-2008 and analyze the volume return intervals \( \tau \), which are time intervals between volume volatilities above a given threshold \( q \). For different threshold \( q \), the probability density function \( P_q(\tau) \) scales with mean interval \( \langle \tau \rangle \) as \( P_q(\tau) = \langle \tau \rangle^{-1} f(\tau / \langle \tau \rangle) \) and the tail of scaling function \( f(x) \) is approximated by power law \( f(x) \sim x^\gamma \). We also study the relation between the distribution function and several factors, including stock lifetime, market capitalization, volume and trading value. There are systematic tendency associated with these factors, suggesting a multi-scaling feature in volume volatility. Moreover, we analyze the conditional probability \( P_q(\tau | \tau_0) \) for \( \tau \) following certain interval \( \tau_0 \), and find \( P_q(\tau | \tau_0) \) depends on \( \tau_0 \), which indicates short-term memory in volume return intervals. In addition, the daily volume volatility shows a long-term correlation, which is similar to the findings in price volatility.
On the stock market globalization using Granger causality and mutual information to the G7

Rui Menezes¹, Andreia Dionisio² and Diana Mendes³

¹ISCTE Business School, Av das Forças Armadas, 1649-026 Lisboa, Portugal, rui.menezes@iscte.pt
²CEFAGE-UE, Univ. of Evora, Largo dos Colegiais, 2, 7000-803 Évora, Portugal, andreia@uevora.pt
³ISCTE Business School, Av das Forças Armadas, 1649-026 Lisboa, Portugal, diana.mendes@iscte.pt

Abstract
This paper analyzes the process of stock market globalization on the basis of two different approaches: Granger causality tests and mutual information tests. While the Granger causality tests are based on regression models and typically capture linearities in the data, mutual information is well suited for capturing global non-parametric relationships in the data without imposing any structure or restriction on the model. The data used in our empirical analysis were drawn from DataStream and comprise the natural logarithms of relative stock market indexes since 1973 for the G7 countries. The main results point to the conclusion that significant causal effects occur in this context and that mutual information and the global correlation coefficient actually provide more information on this process than Granger causality tests, but the direction of causality is difficult to distinguish in the former case. In both cases however there is evidence that stock markets are closely related in the long-run over the 36 years analyzed and, in this sense, one may say that they are globalized.

Keywords
Globalization, market integration, Granger causality, mutual information, global correlation

PACS: 89.65. Gh, 89.70+c, 89.90+n
Analysis and modeling of Japanese business relation network

Wataru Miura¹, Hideki Takayasu², Misako Takayasu¹

1. Tokyo Institute of Technology, Yokohama, Japan
2. Sony CSL, Tokyo, Japan

The link number distribution of business relation network of Japanese companies is known to follow a power law with an exponent about 1.3, confirmed by analyzing the comprehensive data of Japanese companies provided by Research Institute of Economy Trade and Industry. Here, we show that this power law can be explained by combining more basic two properties relating to the age of companies. One is an exponential distribution of age of companies, and the other is an exponential growth of the number of business partners as a function of the age. Taking these properties into account we modify the network growth model originally proposed by Barabási and Albert. In addition to preferential stochastic attachment of new nodes, we added two more effects for directed networks, disappearance of nodes and integration of nodes corresponding to bankruptcy and merger respectively. Intensive numerical simulations show that our artificial network converges to a statistically steady state in which all major network properties are reproduced such as the power law of the connectivity distribution.

We pay attention to the degrees of authority and hub defined for directed networks. As for the real business network it is known that the distribution of degree of hub has a longer tail than that of authority. We show that this property is explained by assigning different values of strength of preferential attachment with respect to in-degree and out-degree.
The Shape of the Growth Rate Distribution decides the type of Non-Gibrat's Law

Atushi Ishikawa ¹, Shouji Fujimoto ¹, Takayuki Mizuno ²

1. Kanazawa Gakuin University, Kanazawa, Japan
2. Institute of Economic Research, Hitotsubashi University, Kunitachi, Tokyo, Japan

In this study, employing exhaustive business data of Japanese firms which approximately encompass the middle and large scale range, the authors confirm as follows. Detailed Balance is observed not only in profits data but also in sales data. The growth rate distribution of sales has wider tails than the linear growth rate distribution of profits in log-log scale. On one hand, in the middle scale range of profits, the probability of positive growth decreases and the probability of negative growth increases symmetrically as the initial value increases. This is called First Non-Gibrat's Law. On the other hand, in the middle scale range of sales, the probability of positive growth decreased as the initial value increases, while the probability of negative growth hardly changes. This is called Second Non-Gibrat's Law. Under Detailed Balance, First and Second Non-Gibrat's Laws are analytically induced from the linear and the quadratic growth rate distributions in log-log scale, respectively. In both cases, the log-normal distribution is deduced from Non-Gibrat's Laws and from Detailed Balance. These analytic results are verified in empirical data. Consequently, it is clarified that the difference of shapes between growth rate distributions of sales and profits is closely related to the difference between two kinds of Non-Gibrat's Laws in the middle scale range.
We analyse Japanese inter-firm network which consists of about one million firms. Links in the network show a business connection between firms. Line weight expresses business size. The network has characteristics of scale-free network. Degree distribution follows a power-law function. Line weight also follows a power-law function. In this presentation, we show basic characteristics of the network among firms. We will also talk about relationships between the network and growth rate of firm-size.
Three power laws in a racetrack betting market and simple voting model

Shintaro Mori ¹, Masato Hisakado ²

1. Department of Physics, School of Science, Kitasato University, Sagamihara, Kanagawa, Japan
2. Standard and Poor’s, Tokyo, Japan

We study the ordering process of horses in racetrack betting markets in Japan Racing Association. Horses are ranked according to the win bet fractions. As the vote progresses, the horses move on the win bet fraction axis. The phase separation between the winning horses and the losing ones occurs.

We see a scale invariant relation between the cumulative distribution function of the winning horse $x_1$ and that of the losing horse $x_0$. $x_1 \propto x_0^\alpha$ holds in the small win bet fraction region. We find two other power laws which characterize the betting process. Both the fluctuation of the win bet fractions and the degree of the phase separation depends on the number of vote $t$ as $t^{-\gamma}$. We also see the emergence of the efficiency of the market as we approach the start of the race.

We introduce a simple voting model and discuss these behaviors. There are three types of betters, independent, herding and fundamental. Based on the power laws in the voting process we estimate the component ratio. The ratio of the independent voters, whose votes are not affected by others’ choices, is about a quarter. The remaining voters are herding whose decisions are determined by others’ choice. Contrary to exchange or stock markets, the appearance of the fundamental voters, who utilize the discrepancy between the present win bet fraction and the true win probability, occurs only in the late stage of the betting process.
The Peter Principle Revisited: A Computational Study

Alessandro Pluchino \(^1\), Andrea Rapisarda \(^1\), Cesare Garofalo \(^2\)

1. Dipartimento di Fisica e Astronomia e INFN sezione di Catania, Università di Catania, Catania, Italy
2. Dipartimento di Sociologia e Metodi delle Scienze Sociali, Università di Catania, Catania, Italy

In the late sixties the Canadian psychologist Laurence J. Peter advanced an apparently paradoxical principle, named since then after him, which can be summarized as follows: “Every new member in a hierarchical organization climbs the hierarchy until he/she reaches his/her level of maximum incompetence”. Despite its apparent unreasonableness, such a principle would realistically act in any organization where the mechanism of promotion rewards the best members and where the mechanism at their new level in the hierarchical structure does not depend on the competence they had at the previous level, usually because the tasks of the levels are very different to each other. Here we show, by means of agent based simulations, that if the latter two features actually hold in a given model of an organization with a hierarchical structure, then not only is the Peter principle unavoidable, but also it yields in turn a significant reduction of the global efficiency of the organization. Within a game theory-like approach, we explore different promotion strategies and we find, counterintuitively, that in order to avoid such an effect the best ways for improving the efficiency of a given organization are either to promote each time an agent at random or to promote randomly the best and the worst members in terms of competence.
Title: Analytical approach to the dynamics of modified rumor-spreading model on scale-free networks
Farinaz Roshani\textsuperscript{a*}, Yaghob Naimi\textsuperscript{b},

\textsuperscript{a} Department of Physics, Alzahra University, Tehran, 19938-91167, Iran.
\textsuperscript{b} Department of Physics, Azad University, Tehran, Iran.

Abstract:
In this paper, we analytically investigate the epidemic spreading for the rumor-spreading model on scale-free networks with new modifications, such as: we use the nonlinear infectivity function to determinate the simultaneous contacts that a given node (individual) establishes to its connected neighbors; we introduce the connectivity strength function (CSF) for the direct link between two connected nodes that leads to degree-busied propagation of rumors. These modifications enter the infectivity exponent $\alpha$ and CSF's exponent $\beta$ in to the analytical rumor model.
We show that one can adjust the exponent $\alpha$ and $\beta$ to control the epidemic threshold which is absent for the standard rumor-spreading model (i.e. rumor model in which each node's infectivity equals its degree and all links have a uniform connectivity strength) on infinite scale-free networks. In addition scale-free network and compare our result with standard model on the same network. We show that the modified model has greater threshold than the standard model.
Inverse halftoning is known as a typical problem in image processing and the purpose is to reconstruct an original image using information on a halftone image expressed as a set of black and white dots which is visually similar to the original image through the human vision system. For this problem, from the viewpoint of statistical mechanical informatics, Saika, et al. investigated the Bayes-optimal solution to inverse halftoning for dither images. Recently, Kanemura et al. studied the Bayesian approach to the problem of superresolution.

In order to develop the previous study, we construct a Bayesian formulation using the maximizer of the posterior marginal (MPM) estimate for the problem of inverse halftoning by making use of the framework of superresolution. We try this approach in the hope that the performance may be improved by utilizing information on a set of the halftone images generated by the dither method using the Bayer-type threshold array and its variants. The Monte Carlo simulation clarifies that the MPM estimate is effective for this problem, if we assume an appropriate model. Then, we investigate the performance of the present method with respect to the number of the dither images which we use in the inverse halftone procedure and the prior knowledge. In addition, these properties are confirmed by the analytical estimate using the infinite-range model.
Boltzmann entropy in a multiplicative asset transfer model

Andrey Sokolov ¹, Andrew Melatos ¹, Tien Kieu ¹,²

1. School of Physics, University of Melbourne, Parkville, VIC 3010, Australia
2. CAOUS, Swinburne University of Technology, Hawthorn, VIC 3122, Australia

In asset exchange models, the exchange of wealth between the agents is reminiscent of the energy-momentum redistribution in a gas. The simplest asset exchange models are closed and conservative, since wealth is conserved in every exchange and there are no net drains or sources of wealth. Therefore, it is appealing to try and apply the technique of entropy maximization, which yields the Maxwell-Boltzmann distribution for an ideal gas, to asset exchange models. Indeed, in a model where the transfer amount is constant and independent of the agents’ wealths, this technique has been found to give an exponential distribution in accord with results for physical systems.

However, in models where the transfer amount depends on the agents’ wealths, such that the stochastic process of exchange is multiplicative, the applicability of Boltzmann entropy is not guaranteed. We consider Boltzmann entropy in a simple multiplicative asset transfer model, the giver scheme, where the transfer amount is proportional to the giving agent’s wealth. In multi-agent simulations of the giver scheme, we observe that the wealth distribution quickly evolves to a steady state. However, we find that the entropy does not evolve monotonically. In the simulations, it grows at first but then turns over and starts decreasing, in conflict with Boltzmann’s H-theorem. We conclude that Boltzmann entropy is not applicable to multiplicative asset exchange models.
Redundant variables and Granger causality

Sebastiano Stramaglia

1. Istituto Nazionale di Fisica Nucleare, Sezione di Bari, Bari, Italia

I will discuss the use of multivariate Granger causality in presence of redundant variables: the application of the standard analysis, in this case, leads to under-estimation of causalities. Using the un-normalized version of the causality index, the notions of redundancy and synergy are quantitatively developed in the frame of causality and two approaches to group redundant variables are proposed: (i) for a given target, the remaining variables are grouped so as to maximize the total causality and (ii) the whole set of variables is partitioned to maximize the sum of the causalities between subsets.

The application to a real neurological experiment, aiming to a deeper understanding of the physiological basis of abnormal neuronal oscillations in the migraine brain, is described. The outcome by the proposed approach reveals the change in the informational pattern due to repetitive transcranial magnetic stimulations.
structural motif-based classification of nodes in Japanese inter-firm network

Takaaki Ohnishi 1,2, Hideki Takayasu 3, Misako Takayasu 4

1. The Canon Institute for Global Studies, Chiyoda-Ku, Tokyo, Japan
2. Graduate School of Economics, The University of Tokyo, Bunkyo-Ku, Tokyo, Japan
3. Sony Computer Science Laboratories, Shinagawa-ku, Tokyo, Japan
4. Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology, Midori-ku, Yokohama, Japan

To understand a firm’s economic activity, it is important to investigate not only the firm itself but also the structure of interactions on an inter-firm network. Traditional measures for analyzing complex networks, such as the clustering coefficient and the shortest path length have been widely employed to clarify the structural properties. However, they are not always useful, because these measures ignore link directions and are intended for undirected networks. Complex networks have numerous patterns of connections. Subgraphs that occur significantly more often in the real network than in randomized networks are referred to as motifs, while those occurring less frequently are anti-motifs. Recently, network motifs have attracted attention as a tool for studying directed networks.

We empirically analyze Japanese inter-firm network consisting of about one million firms and four million directed links. Firms are represented by nodes and directed links mean transactions. The directed link stands for flow of money, and the direction of link is from customer to supplier. By specifying network motifs, we found that V-shaped triads are network motifs, while feedforward and feedback loop are anti-motifs. By defining roles in the subgraph according to structural equivalence, we also detected the significance profile of roles characterizing the industry sector. The clusters obtained using the significance profile of roles are economically meaningful, implying that we can extract important information from the local structure of the directed network.
Telecommunication, compressed sensing and correlated randomness

Koujin Takeda ¹, Atsushi Hatabu ², Yoshiyuki Kabashima ¹

¹. Tokyo Institute of Technology, Yokohama, Japan
². System IP Core Research Laboratories, NEC Corporation, Kawasaki, Japan

We discuss how to analyze performances of telecommunication system and compressed sensing with correlated randomness from the viewpoint of statistical mechanics. First we propose an approximate method for random-averaged performance of linear-vector telecommunication channel with correlated random channel matrix by using matrix integration of gaussian orthogonal ensemble (GOE), despite breakdown of orthogonal invariance due to correlated randomness. Though this method is an approximation, we found that the deviation of the result from exact analysis is very small if correlation in randomness is also small, which enforces the utility of this method in some cases. Next we discuss how to deal with correlated random matrix in telecommunication system in an exact manner. This method can be applied to the performance analysis of the Kronecker channel in the Multiple-Input-Multiple-Output (MIMO) telecommunication system, and we can obtain the exact expression of mutual information of this channel. We can also apply this method to compressed sensing with correlated compression process, which allows us to estimate the critical compression rate for successful reconstruction of original input signal.

Random process leading to the non-Maxwellian distribution of self-gravitating systems

Tohru Tashiro

Department of Physics, Ochanomizu University, 2-1-1 Ohtuka, Bunkyo, Tokyo 112-8610, Japan
E-mail address: tashiro@cosmos.phys.ocha.ac.jp

When describing the steady state of a self-gravitating system (SGS) where many particles interact via the gravitational force, we cannot use the Maxwell-Boltzmann distribution. Actually, the real systems in the universe, e.g. globular clusters, galaxies etc., have various non-Maxwellian structures. As for the most of globular clusters, it is known that the number densities of them in the real space have a flat core and behave as a power law outside the core. We derive such a non-Maxwellian distribution of SGS around the core by a model based on the random process with the additive and the multiplicative noise. The number density can be obtained through the steady state solution of the Fokker-Planck equation corresponding to the random process. We exhibit that the number density becomes equal to the density profiles around the core of globular clusters and our numerical simulation by adjusting the friction coefficient and the intensity of the multiplicative noise.
Competition of updating dynamics in evolutionary games on networks: the prisoner's dilemma case

Daniele Vilone ¹, Angel Sánchez ¹, Jesús Gómez-Gardeñes ²

1. Departamento de Matemáticas, Universidad Carlos III de Madrid, Leganés (Madrid) – Spain;
2. Departamento de Matemática Aplicada, Universidad Rey Juan Carlos, Móstoles (Madrid)- Spain.

The evolution of cooperation in systems of interacting agents is a very debated issue: in particular, the influence of the population structure (described by a network) on the emergence of the cooperation has been widely studied in the last two decades. Several social dilemmas have been considered (Prisoner’s Dilemma Game, Stag Hunt, Snowdrift) as well as different kinds of networks: regular lattices, random networks, etc.

In this work we present a detailed numerical analysis of the impact of different topologies (euclidean, small-world, Erdos-Renyi and scale-free networks) on the behaviour of a population playing the Prisoner's Dilemma game. At variance with the studies carried up to date, we study the dynamical evolution of both the strategies of the players (cooperation and defection) and their updating rules (unconditional imitation, replicator, and Moran). Therefore, we let the system evolve to naturally select the fittest strategy and update mechanism. Our results support two main conclusions. First, the shortcuts introduced in a small-world topology have a dramatic effect on the emergence of cooperation and the competition of rules; and, second, increasing the heterogeneity of the network favours probabilistic updating rules against unconditional imitation leading, as a consequence, to a more cooperative global behaviour.
Phase transitions by means of information theory

Eugenio E. Vogel, Vasco Cortez, Gonzalo Saravia

Department of Physics, Universidad de La Frontera, Temuco, Chile

Magnetic systems (ferromagnets, antiferromagnets, spin glasses) show ordered phases over a certain critical temperature $T^*$. A site order parameter $q$ can characterize the existence of an ordered phase and $T^*$ based on two methods: The crossing of Binder cumulants and, more recently, the crossing of autocorrelations functions both associated to $q$. In this contribution we present a new method to find $T^*$: looking for the maximum size or weight of the compressed files storing the evolution of the same order parameter, simulated at different temperatures.

A Monte Carlo (MC) procedure is defined to simulate the time evolution of the order parameter after equilibration at a certain temperature $T$. The system is allowed to evolve for 2.400.000 MC steps. Values of the order parameter are recorded every 20 MC steps. All files are compressed. It is found that the weights of such files maximize at $T^*$. Calculations are repeated for different concentration $x$ of antiferromagnetic interactions substituting for originally ferromagnetic interactions in a saturated lattice. Different three dimensional lattice sizes are included. A complete analysis of the phase diagram with respect to $x$ and $T$ is produced. A qualitative reasoning justifying this method is given. The possible application of this method to other critical and/or chaotic phenomena is discussed.
Time-lag Magnitude Cross-Correlations in Collective Phenomena

Duan Wang\textsuperscript{1}, Boris Podobnik\textsuperscript{1,2}, Davor Horvatic\textsuperscript{3}, Ivo Grosse\textsuperscript{4}, and H. Eugene Stanley\textsuperscript{1}

\textsuperscript{1}Center for Polymer Studies and Department of Physics, Boston University, Boston, MA 02215
\textsuperscript{2}Faculty of Civil Engineering, University of Rijeka, Rijeka, Croatia
\textsuperscript{3}Department of Physics, Faculty of Science, University of Zagreb, Zagreb, Croatia
\textsuperscript{4}Martin Luther University, Institute of Computer Science, 06120 Halle, Germany

Abstract

We study long-range magnitude cross-correlations in collective modes of real-world data from finance, meteorology, physiology, and genomics using time-lag random matrix theory. We find long-range magnitude cross-correlations (i) in time series of price fluctuations, (ii) in time series of atmospheric pressure, (iii) in physiological time series, both healthy and pathological, indicating scale-invariant interactions between physiological time series, and (iv) in ChIP-seq data of the mouse genome, where we uncover a complex interplay of different DNA-binding proteins, resulting in power-law cross-correlations ranging up to 10 million base pairs. Based on analysis of singular vectors and singular values (a) in finance we find that sudden change in them are largest in times of crisis: (b) in physiology we find statistically significant differences between alcoholic and control subjects.
Plefka expansion of replica extended Ising model and its application to inverse Ising problem

Muneki Yasuda ¹, Yoshiyuki Kabashima ² and Kazuyuki Tanaka ¹

1. Graduate School of Information Sciences, Tohoku University, Japan
2. Department of Computational Intelligence and Systems Science, Tokyo Institute of Technology, Japan

In recent information sciences techniques of the mean-field theory are widely utilized as computationally feasible approximate inference algorithms [1]. In this presentation we take notice the inverse Ising problem which is known as an important machine learning problem in information sciences. Given data, magnetizations and correlation functions, the inverse Ising problem is to determine suitable parameters, physical fields and couplings. Many algorithms based on mean-field methods, for example the Bethe approximation and so on, have been proposed to solve this problem [2]. However, most of such algorithms break down in high-correlated ‘glassy’ data, because they do not take the replica symmetry breaking (RSB) into account.

A replica extension technique has been developed for the purpose of investigating systems in RSB phase, and it has succeeded to reproduce the survey propagation from a variational principal point of view [3]. In the presentation, we apply the Plefka expansion [4] to the replica extended models. Our scheme systematically gives a series of high temperature expansion associated with the 1-step RSB ansatz. We first show that for the Sherrington-Kirkpatrick model, this leads to the 1-step RSB version of the Thouless–Anderson–Palmer equation [5]. Next, we apply the expansion scheme to the inverse Ising problems and give an explicit algorithm to solve them. Since our new algorithm can treat data in the RSB phase, in which the conventional algorithms based on mean-field methods break down, it can be expected to facilitate the development of algorithms of inverse Ising problems.