Evolutionary Game Theory and Its Application to the Financial Market Microstructure

Mitsuru KIKKAWA

Position Title,Affiliated Department ：Doctoral course second grader, Fundamental Science and Technology Program, Graduate School of Science and Technology, Meiji University

Team Fellow ：Masayasu MIMURA(Mathematical Analysis) Naoki MATSUYAMA(Modeling), Daishin UEYAMA(Simulation)

Research Description ：Evolutionary game theory and its applications.

Research Outline

To solve several economic problems of today, we need to analyze the mechanism in complex economic phenomena. In addition, there are several types' players behind the economic phenomena and we need to understand the players' decision making and their behavior. I have researched evolutionary game theory and its applications to the financial market structure focused on the player's bounded rationality behavior.

1. Theoretical Study

1) **Convergence to Nash equilibrium and equilibrium selection with the Bayes learning**: I extended Kalai and Lehrer (Econometrica,1993), which examined the convergence of the strategies of players with using Bayes learning to the Nash equilibrium, to be applicable even in games where only mixed strategies were Nash equilibrium. In particular, I proved it focused on the martingale convergence to the expected payoff. Furthermore, equilibrium selection was examined in the case of likelihood which is binomial distribution or normal distribution as an example.

2) **Common property resource games with nonlinear utility function**: In the common property resource game, which resources become depleted if each player with linear utility function behaves selfishly (Sethi and Somanathan Amer. Econ. Rev., 1996), it was expanded that each player has nonlinear utility function and derived the conditions which each player chooses cooperative action under an indirect evolutionary approach. The game was further extended to those between players with different asset levels and the conditions which each player choose cooperative action were derived in the same way.

3) **Game theory for empirical analysis**: To demonstrate an empirical analysis of economical phenomena with game structure, game theory with using the statistical population, which is the second interpretation of the Nash equilibrium, was formulated with Kikkawa (Prog. Theor. Phys., 2009). Assuming an evolutionary approach, the game was expanded to the dynamical framework. As an example, I demonstrated the zero-sum game and the order book in the financial market and derived Nash equilibrium by re-defining the subjective payoff matrix which is own utility for each player in the game.

2. Application: Financial Market Structure

The financial market model formulated with using the double auction theory (c.f. Chatterjee and Samuelson, Oper. Res., 1983) was re-considered to examine the financial market microstructure theoretically and demonstrate an empirical analysis. The results found that investors do not trade rationally and rush to submit the order in some cases. In particular, by using the relationship derived in theoretical research 3), it was empirically founded that the variance of expected payoffs and distribution of volume was proportional to the difference of the reservation price between investors.

Verification of Government Bond Pricing Model using Market Data

Eiichi DOI

Position Title,Affiliated Department ：Doctoral course second grader, Fundamental Science and Technology Program, Graduate School of Science and Technology, Meiji University
Takeaki KARIYA (Modeling)

Team Fellow ：Toshikazu SUNADA (Mathematical Analysis), Kyosui OH (Simulation)
Empirical study on the cross-sectional market (CSM) model to

Research Description ：estimate government bond price from market data

Research Outline

In Japan, the fiscal burden is anticipated to grow ever greater in the future with slow economic growth, sluggish tax revenues, and the ageing of the baby boomers. Government bonds will hence undoubtedly need to play an increasingly larger role in fund procurement.

Under these circumstances, an experimental study on the cross-sectional market (CSM) model for government bond pricing proposed by Kariya (1995) was conducted based on the convenient characteristics of national government bonds, which can be assumed to have no credit risks. We also examined the expansion of models based on the results. The characteristics of the CSM model include the assessment of the variations in pricing due to the difference in attribute information of government bonds (coupon and redemption period). These are called a coupon effect and the effect of different maturity stages. To calculate the present value of government bonds, the CSM model capitalizes fixed cash flow value in the future using the attribute-dependent stochastic discount function of each bond at each time cash flow occurs. The formulation of the attribute-dependent stochastic discount function includes, as attributes, coupon size and time until the redemption period, which are thought to affect government bond pricing. The generalized least-squares method using market price data is applied to estimate parameters based on inter-bond correlations described by attributes.

After completing formulations for the review as well as building the system serving as the basis of the review, we started working on our experimental study. To establish models capable of explaining market price more precisely, validations, improvements, and comparisons with conventional models are under way.

In addition, we have also examined the model if it is useful to predict the changes (yield curve) in earning yields without taking into account the degree of impact of coupon effects, effects of different maturity stages, or attributes in market trades of government bonds.

Study on Spiral Dynamic Coexisting State of Three Competing Populations

Makoto TOHMA

Position Title, Affiliated Department : Doctoral course second grader, Fundamental Science and Technology Program, Graduate School of Science and Technology, Meiji University

Team Fellow : Masayasu MIMURA(Mathematical Analysis) Joe Yuichiro WAKANO (Modeling), Daishin UEYAMA(Simulation)

Research Description : Pattern formation mathematics in the reaction-diffusion system

Research Outline

Since 2009, we have been investigating the assertion of "in the natural world, complex networks are formed owing to the complex competition between not only two populations but among many populations, which eases fierce competition and enables coexistence" in studies centering around numerical experiments using model equations based on reaction-diffusion systems. The model equation system used in the studies is the following reaction-diffusion system in the bounded convex domain (Ω) of a two-dimensional space:

$$\tfrac{\partial}{\partial t} u_i = d_i \Delta u_i + f_i(u_1,\cdots,u_N), t > 0, x \in \Omega, (i = 1, \cdots N)$$

where reflective boundary conditions are given as boundary conditions and appropriate non-negative functions are given as initial conditions. The nonlinear term f is limited according to the following equation:

$$f_i(u_1,\cdots,u_N) = (r_i - a_i u_i - \sum_{i \neq j}^{n} b_{ij} u_j) u_i$$

We also studied the partial differential equation system in a one-dimensional infinite domain due to reasons described later.

With this system, if $N = 2$, the competitive exclusion principle is established. If $N = 2$ and the model equation is handled in a one-dimensional infinite domain, heteroclinic traveling-wave solutions exist, where one population eliminates other populations. If $N = 3$, the strength of the three populations competing is the same, and the diffusion effects are ignored and competitive exclusion is established. However, Ei Ikota and Mimura (1999) found that the addition of a diffusion term causes the segregated areas to form a dynamic pattern, which enables coexistence in some cases.

For an invading population weaker than the existing two populations, wherein it does not survive without diffusion effects, the coexistence state in which a dynamic spiral pattern is formed and none of the three populations die was recently discovered mathematically. In parameter areas where the spiral pattern is formed, mathematical analysis demonstrated that the presence of heteroclinic nontrivial stable traveling waves is related to all three variables.

The focus of our research continued from the last fiscal year to be on the relation with traveling waves in one-dimensional infinite domains to understand the dynamic spiral coexistence state in detail. As part of the research, we mathematically analyzed the bifurcation structure of traveling waves to clarify their stability. First, we targeted the bifurcation structure of heteroclinic nontrivial stable traveling waves as parameters controlling b_{23}. In the area where the limit point is reached, the unstable branch is returned, and spiral patterns are formed if b_{23} is small, the presence of both stable and unstable nontrivial traveling waves was identified by mathematical analysis. Furthermore, the presence of homoclinic nontrivial stable traveling waves combining stable nontrivial and trivial traveling wave solutions was confirmed. The analysis of the bifurcation structure of the homoclinic traveling waves confirmed that Hopf bifurcation and periodic vibration wave solutions occur depending on the b_{23} changes. In parameter areas where Hopf bifurcation occurs, the formation of complex comma-shaped spiral patterns was confirmed in two-dimensional problems. Although a relation between the complex patterns of two-dimensional problems and Hopf bifurcation of one-dimensional problems was estimated to exist, we were not able to obtain clear results in FY2010.

As related studies, we are also investigating the stability and bifurcation structure of quasi-exact stationary solutions for three competing populations discovered by L.C. Hung *et. al*.

Some results of the research were presented in the research seminar on Recent Themes on Partial Differential Equation System in April 2010 in Beppu and the Mathematical Modeling and Analysis Mini-symposium for Young Researchers on Stable Coexistence by Evolution and Morphological Formation of Reaction-Diffusion Systems in August 2010.

Development of Method for Measuring Effects of Advertising using Design of Experiments and Time Series Analysis

Tetsuji HIDAKA

Position Title, Affiliated Department ： Doctoral course second grader, Fundamental Science and Technology Program, Graduate School of Science and Technology, Meiji University

Team Fellow ： Yasunori OKABE (Modeling), Masayasu MIMURA (Mathematical Analysis), Kazuyuki NAKAMURA (Simulation)

Research Description ： Study on advertising effects on brand sales and values using time series analysis

Research Outline

As in the last fiscal year, we continued our ongoing research on measuring the effects of advertising. Given the changes in the environment surrounding advertising in recent years, some midterm corrections have been made to the measurement method, etc. In the past, measurement of advertising effects and brand diagnosis were mainly done using point-of-sale (POS) data and by questionnaire surveys. In recent years, given the growing popularity of the brain science approach in the marketing field, services measuring and analyzing brain waves (electroencephalogram, EEG) have been increasing rapidly. In response, we added the new theme of developing analytical methods for providing better measurement and analytical services for the current fiscal year.

EEG enables controlled experiments based on the theory of design of experiments, which is included in the title of the article. The time series analysis, also shown in the title, can also be applied to EEG. On the other hand, POS data provides real market information, but controlled experiments are impossible. Therefore, EEG may become the ideal measurement method in the future.

However, EEG posed several problems if actually measured. The first is the problem of the burden on the subjects being measured. As they need to wear headsets with wet electrodes, their heads become wet with the cleaning solution during the process. Subjects are thus reluctant to participate, and natural psychological states cannot be maintained. The next is the problem of measurement noise. As brain waves are micro electromagnetic waves, muscle potential such as blinking of eyes is stronger, erasing the required information. The third is the problem of the cycle. If complete periodic data is available, information can be obtained from frequency analysis, but because the cyclic nature itself changes with time, and the time interval is very short, it is difficult to handle. The last is the problem of nonlinearity. As expected to a certain degree from precedent studies, data that cannot be handled when traditional linear models are used was obtained.

The first problem will be solved sooner or later given the rapid progress of measurement devices. Already as of 2011, inexpensive devices using dry electrodes were announced. As for the second problem, we have made comprises on the policy of eliminating noise according to the results of precedent studies. Specifically, a high frequency filter and independent component analysis are used to eliminate muscle potential such as blinking of the eye. However, as this method may eliminate useful information by mistake at the same time, it remains a task to be solved in the future. As for the third problem, the theory of KM_2O-Langevin equations was improved, instead of applying time-frequency analysis, to examine the quality of data without being affected by the frequency components. To demonstrate its practicality, the effectiveness of the method was verified by analyzing the dynamics of the sunspot number data, and the next sunspot number peak was predicted.

To solve the last problem, the methods for studying the properties of nonlinearity were under investigation by applying chaos analysis in addition to the results of the theory of KM_2O-Langevin equations. A method to measure emotions according to nonlinearity is also under investigation.

Evolutionary diversification and the influence of Allee effect in a predator–prey system

Jian ZU

Position Title,Affiliated Department ：Doctoral course second grader, Fundamental Science and Technology Program, Graduate School of Science and Technology, Meiji University

Team Fellow ： Masayasu MIMURA(Mathematical Analysis) Joe Yuichiro WAKANO (Modeling), Daishin UEYAMA(Simulation)

Research Description ：Elucidation of biological systems by Mathematical Modeling and Analysis

Research Outline

Understanding the mechanism of evolutionary diversification and the influence of Allee effect remains the core problems in evolutionary biology. In this year, I have done the following work.

First, we investigated the influence of Allee effect in a predator–prey system with Holling type II functional response. Compared with the predator–prey model without Allee effect, we find that the Allee effect of prey species increases the extinction risk of both predators and prey. When the handling time of predators is relatively short and the Allee effect of prey species becomes strong, both predators and prey may become extinct. Moreover, it is shown that the model with Allee effect undergoes the Hopf bifurcation and heteroclinic bifurcation. The Allee effect of prey species can lead to unstable periodical oscillation. It is also found that the positive equilibrium of the model could change from stable to unstable, and then to stable when the strength of Allee effect or the handling time of predators increases continuously from zero, that is, the model admits stability switches as a parameter changes. When the Allee effect of prey species becomes strong, longer handling time of predators may stabilize the coexistent steady state. This paper has been published in *Applied Mathematics and Computation* (2010, 217(7): 3542-3556).

Second, with the method of adaptive dynamics and geometric technique, we investigated the adaptive evolution of foraging-related phenotypic traits in a predator–prey community with trade-off structure. Specialization on one prey type is assumed to go at the expense of specialization on another. First, we identify the ecological and evolutionary conditions that allow for evolutionary branching in the predator phenotype. Generally, if there is a small switching cost near the singular strategy, then this singular strategy is an evolutionary branching point, in which the predator population will change from monomorphism to dimorphism. Second, we find that if the trade-off curve is globally convex, the predator population eventually branches into two extreme specialists, each completely specializing on a particular prey species. However, if the trade-off curve is concave–convex–concave, after branching has occurred in the predator phenotype, the two predator species will evolve to an interior singular dimorphism at which they can continuously stable coexist. The analysis reveals that an attractive dimorphism will always be evolutionarily stable and that no further branching is possible under this model. This work has been published in *Journal of Theoretical Biology* (2011, 268(1): 14-29).

Third, I finished the Ph.D. dissertation and got the Ph.D. Degree in this year.

Overall, during the past year, I have done some interesting work. I greatly improved my research ability and learned a lot of methods and techniques to deal with the evolutionary problems in ecology.

Understanding the Diversity of Bacterial Colony Patterns

Akihiro AOTANI

Position Title,Affiliated Department ： Doctoral course first grader, Fundamental Science and Technology Program, Graduate School of Science and Technology, Meiji University

Team Fellow ： Masayasu MIMURA(Mathematical Analysis), Ryo KOBAYASHI, Hiraku NISHIMORI (Modeling), Daishin UEYAMA(Simulation)

Research Description ： Modeling and analysis of bacterial colony patterns

Research Outline

Budrene and Berg (1991) observed three types of colony with different geometric patterns in response to changing only the nutrient element concentration in the culture of chemotactic *Escherichia coli* (*E. coli*) strains (HCB317tsr) in agar medium. They gave four reasons for the development of these patterns: multiplication of bacteria due to nutritional intake, random motion, chemotactic agents, and chemotactic migration. They also suggested that the patterns are formed not due to genetic control but in a self-organized manner when these four factors are in appropriate balance, but gave no explanation.

We succeeded in reproducing patterns similar to actual colonies in terms of the final patterns and the formation process by setting appropriate conditions and defining the nutrient element concentration as the free parameter in the Mimura-Hiroyama model (2002) (Figure). The results suggest that *E. coli* may be able to form colony patterns with geometric structures, self-organizedly by appropriately balancing nutritional intake and chemotactic migration.
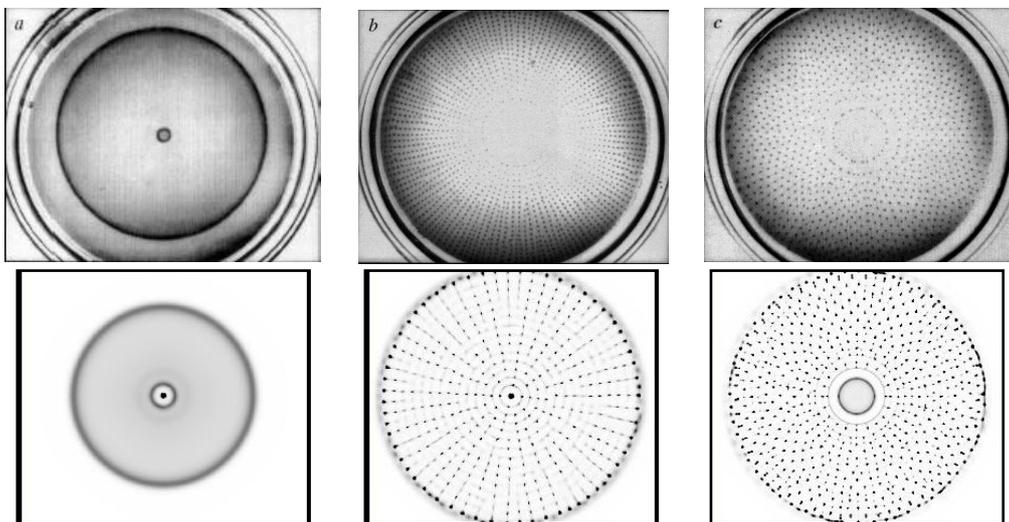
Figure: Colony patterns formed by experiments and reproduction by simulation

Based on the results discussed, our study has focused on the following activities:

(1) Discuss the validity of multiplication, chemotaxis, and secretion and other functions given for building models from a biological viewpoint.
(2) Investigate model equations from a mathematical viewpoint, specifically in terms of the existence of solutions, asymptotical behavior, and global structure of equilibrium solutions (parameters).
(3) Provide new insight into the mechanism of forming colony patterns of chemotactic *E. coli* through mathematical model analysis and simulation.

Methods for Wind Power Generation Prediction and Confidence interval Estimation

Tatsuya IIZAKA

Position Title,Affiliated Department ： Doctoral course first grader, Fundamental Science and Technology Program, Graduate School of Science and Technology, Meiji University

Team Fellow ： Masayasu MIMURA(Mathematical Analysis) Joe Yuichiro WAKANO (Modeling), Daishin UEYAMA(Simulation)

Research Description ： Intelligent systems of electric power system

Research Outline

Wind power generation has been consistently installed around the world as a means of preventing global warming. Despite the advantage of emitting no CO_2, its large output fluctuations are feared to have an adverse impact on electric power systems. It is hence important to calculate predictions of future wind power generation and error margins of such predictions (confidence interval), and control output fluctuations using these values.

For the FY2010 study, the regression equation and fuzzy inference were used to estimate wind speed to the next day, the confidence interval of wind speed, output, and the confidence interval of output, with the weather forecast grid point values (GPV), which the meteorological agency mathematically calculates for approximately 20-km meshes as the input information.

Wind speed prediction is comprised of three steps. In the first step, wind speed at the height of the windmill is estimated using the weather forecast GPV as the input. In the second step, the wind speed is corrected to that at the point of the windmill, and in the third step, the predicted wind speed in several hours are corrected based on the current predicted error.

The confidence interval of the wind speed is calculated using fuzzy inference based on the wind speed and target time of prediction.

In wind farms with several windmills, the output of windmills on the leeward is occasionally reduced by those located on the windward. We therefore constructed a calculating model for output based on the wind direction and wind speed using another fuzzy inference.

Figures 1 and 2 show the results of predictions calculated using the proposed method. The results show the effectiveness of the proposed method, because almost all of actual output are within the estimated confidence interval.
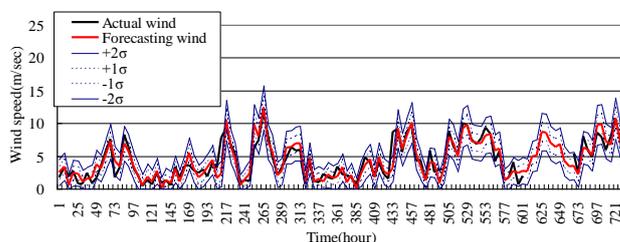

Figure 1
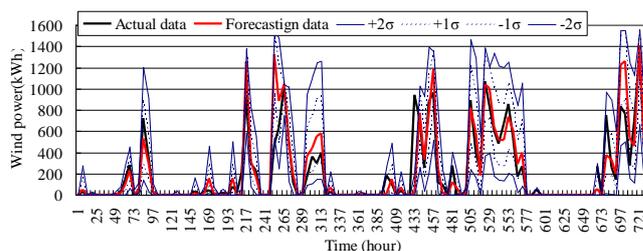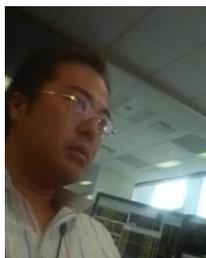Wind speed predictions and confidence interval (predictions at one hour ahead)

Figure 2
Output predictions and confidence interval (predictions at one hour ahead)

Market Analysis of Market Microstructures

Kazuhiro MUKAIDONO

Position Title,Affiliated Department ： Doctoral course first grader, Fundamental Science and Technology Program, Graduate School of Science and Technology, Meiji University

Team Fellow ： Takeaki KARIYA (Modeling)
Koji INUI (Mathematical Analysis), Yoshiro YAMAMURA (Simulation)

Research Description ： Market Analysis using market microstructures

Research Outline

The aims of the study were to analyze investment actions related to pricing and trading methods in the Japanese stockmarket and other exchange transactions based on the results of market microstructure research, which has been gradually growing in recent years; investigate and present factors enhancing market polarity and systematic problems; and explore and verify investment opportunities in the stockmarket while taking into account elements related to behavioral finance. My work experience in the stockmarket was used for the study as necessary.

Numerous fundamental investment opportunities were identified by applying knowledge obtained through my practical business experience, and the ideal price assessment methods of such investment opportunities were examined. Investment opportunities have been visualized based on these market data, using statistical software and calculation methods. High frequency market data (tick data) were usually used to verify analyses on current high frequencies (high frequency trades), algorithmic trading (automated trading), and various basket trades.

Existing studies and the reports of sell-side brokers were reviewed. If I am able to discover trading opportunities that would have been impossible to discover myself, I hope to expand them further by combining my own experience.

The main methods include statistical data analysis and simulations based on stochastic models to clarify the relation between past stock price changes and trading systems and rules of the stock exchanges. Prior to these validation analyses, I have reviewed studies on asset price theories and the market microstructure, and am currently selecting candidate models for analysis.

The objective, method, and anticipated results of this study differ significantly from those of conventional studies assuming efficient markets because ideas obtained from personal work experience are used. Well aware that the new approach entails the risks of failing to obtain the expected results, I will give priority to analysis focusing on trading opportunities, which is believed to be particularly important based on practical experience. To obtain results that can be practically applied, efforts to consistently produce universal and systematic results must be made.

Development of Mesh Generation Method using Self-Organization Mechanisms of Reaction-Diffusion System

Masahiro YAMAGUCHI

Position Title,Affiliated Department : Doctoral course first grader, Fundamental Science and Technology Program, Graduate School of Science and Technology, Meiji University

Team Fellow : Daishin UEYAMA(Simulation), Masayasu MIMURA(Mathematical Analysis), Toshiyuki NAKAGAKI (Modeling)

Research Description : Development of new application model inspired by pattern formation process of living organisms

Research Outline

We developed a new mesh generation method applying the characteristics of spontaneous pattern formation in reaction-diffusion systems. With the Gray-Scott (GS) model, a type of reaction-diffusion system, equally-spaced spot patterns are formed according to the shape of the calculated region. If spatially non-uniform diffusion coefficients are used, the space between spots can be continuously changed. By dividing the analyzed region taking these spots as the nodes, we believe that mesh can be generated for the finite element method (FEM), which is a numerical solution for partial differential equations. The advantages of this approach are that it can be applied to complex shapes, and that a standardized program can be used to produce mesh in which the size of elements is controlled in any coordinate. As new spots are spontaneously created in response to an increase in the calculated region, this mesh generation method may be adaptable to enlargement and deformation of the analyzed region. Using the self-organization mechanisms of reaction-diffusion systems, we developed a triangular mesh generation method for any shapes in the two-dimensional space (Figure 1). The results of the study were presented in the poster session of the FY2010 annual conference of the Japan Society for Industrial and Applied Mathematics, and received the Best Poster Award[1].
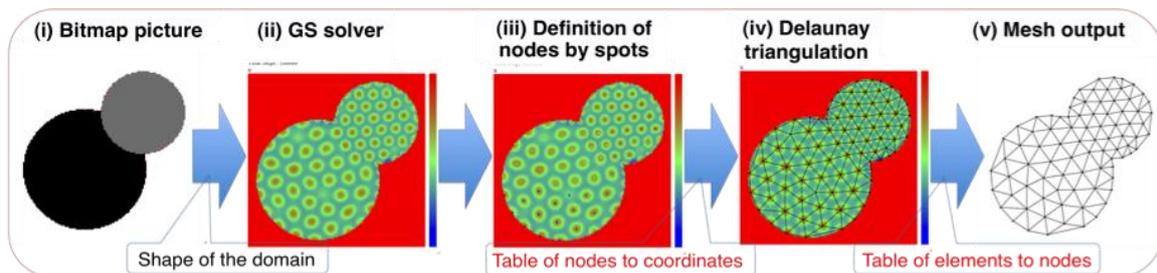

Figure 1 Outline of mesh generation process

[1] 1st Young Researcher Best Poster Award in FY2010, Japan Society for Industrial and Applied Mathematics

http://www.jsiam.org/modules/xfsection/article.php?articleid=82

Asymptotic behavior of solutions of reaction-diffusion equations

Yan-Yu CHEN

Position Title,Affiliated Department : Doctoral course first grader, Fundamental Science and Technology Program, Graduate School of Science and Technology, Meiji University

Team Fellow : Hirokazu NINOMIYA (Mathematical Analysis), Masayasu MIMURA (Modeling), Guo Jong-Sheng (Simulation),

Research Description : Mathematical characterization of patterns appearing in reaction diffusion systems

Research Outline

Many physical/chemical phenomena are represented by the partial differential equations. Among them I am interested in the reaction-diffusion systems, which includes the kinetic dynamics and diffusion process as follows:

$$u_{j,t} = d_j \Delta u_j + f_j(u) \qquad (j = 1, \ldots m) \qquad \text{(RD)}$$

This system looks simple, but it is important to study the behavior of solutions. For example, the dynamics of tissue formation and angiogenesis is also represented by a couple of reaction-diffusion equations with three components.

To reveal the dynamics of solutions of (RD) we need to study the attractor because all solutions converge to the attractor. It is difficult to investigate the attractor of the reaction-diffusion system in general. So we consider the simplest case as the first step. Now we are treating the following reaction-diffusion equation on R :

$$u_t = u_{xx} + f(u) \qquad \text{(AC)}$$

which is called Allen-Cahn equation. Here $f(u)$ is C^2 on an open interval containing $[0,1]$ and

$$f(0) = f(a) = f(1) = 0, \quad f'(1) < 0, \quad f'(0) > 0.$$

The equation possesses three homogeneous stationary solutions: 0, a, 1. The two equilibriums are stable, one is unstable under the flow by the ordinary differential equation. The several types of traveling wave solutions are already known. They belong to the attractor of (AC). Now, we are trying to construct the new type of the entire solution of this equation. In professor Ninomiya and Morita's work, we know the existence of entire solutions with merging two fronts. Here, we show that one of the dynamic of this entire solution.

Entire solution with merging two fronts
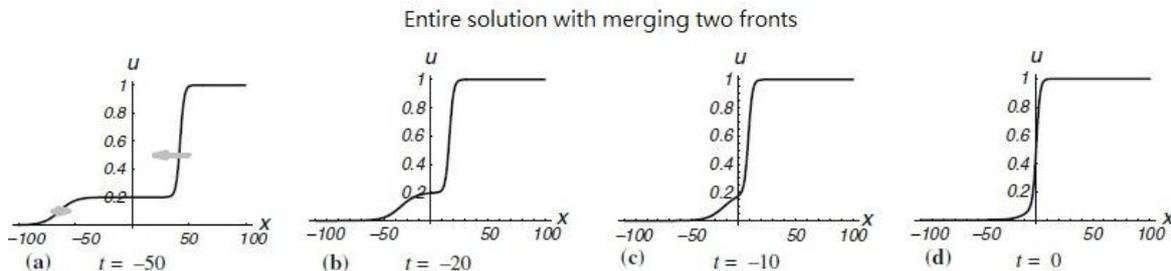
In fact, there are other kinds of entire solutions. We expect there are entire solutions with merging three fronts or four fronts. Through studying the entire solution, we can obtain more information about the structure of the attractor. As the next step, we will apply this method to the reaction-diffusion systems. Furthermore, the result can help us to understand the pattern in the reaction-diffusion system more clearly.

Development of criteria for information security of smart grid system

Ai Ling Amy POH

Position Title, Affiliated Department : Doctoral course first grader, Fundamental Science and Technology Program, Graduate School of Science and Technology, Meiji University

Team Fellow : Masao MUKAIDONO (Modeling), Masayasu MIMURA (Mathematical Analysis), Kokichi SUGIHARA (Simulation)

Research Description : Information security system of smart grid

Research Outline

Significance of research: A smart grid can help utilities conserve energy, reduce costs, increase reliability and transparency, and make processes more efficient. The increasing use of IT-based electric power systems, however, increases cyber security vulnerabilities, which increases cyber security's importance. This project looks into the security system of Smart Grid via Smart Planet system, focused on the selection of the model in developing information security criteria on smart grid. The importance of information security criteria is the main aspect perceived to impact customer trust towards the entire smart grid system.

Purpose of research: When the information is shared real-time between power generator, distributed resources, service provider, control center, substation, even to end-users, any changes expose to hacker's attack would bring the whole system down to mess. This will dangerously create consumer distrust and dissatisfaction that may lead to other more destructive phenomenon. This project identified the criteria that could enhance information security system of a smart grid project and discussed about the impact and significance of each requirements identified.

Research content: In order to realize the Smart Grid, data are gathered from large numbers of intelligent sensors and processors installed on the power lines and equipment of the distribution grid. These data collected will be transferred to central information processing systems which both present the information to operators and use the information to send back control settings. While information and communication seems to be much more importance compare to decades ago, the system has to be mightily strong to protect itself against hacker's attack. This project explains the importance of information security and the information security's impact on consumer trust and satisfaction in a mind mapping portrayed in the figure at the bottom.

Expected achievement: Design to prove that there is a significant positive relationship between the consumer requirement and functional requirement elements with the help of fuzzy logic value which would serve to eliminate ambiguity during data insertion and validation. The project takes aim to reveal the significant information security criteria in a smart grid that would impact consumer's trust and satisfaction towards the entire system.