Program

March 8 (Monday)

Below timetable is Taiwan time. Add 1 hour for Japanese side.

8:50-9:00 **Opening**		
9:00-9:55 **Session 1**		Chair: Yue-Hong Li (National Cheng Kung University)
	9:00-9:15	Kai-Yang Liu (National Yang Ming Chiao Tung University, M2) *Lyapunov functions for some epidemic models with delay*
	9:15-9:30	Kaito Fujihara (Shimane University, M2) *Mathematical study on hidden emotions and body patterns observed in Cuttlefish*
	9:30-9:45	Tsuyoshi Ishizone (Meiji University, M2) *A method to infer latent dynamics model by combining deep neural networks with ensemble Kalman filter*
	9:45-9:55	Chun-Sheng Chen (National Central University, B) *The data forecast of COVID-19 by method of machine learning*
10:20-11:20 **Session 2**		Chair: Masakazu Kuze (Hiroshima University)
	10:20-10:35	Yusuke Fujita (Hiroshima University, M2) *Why do two-dimensional dunes always merge*
	10:35-10:50	Yu-Jie Ho (National Yang Ming Chiao Tung University, M1) *The Second Laplacian Eigenvalue*
	10:50-11:05	Ryu Fujiwara (Meiji University, M2) *Discontinuous steady states of the nonlocal Allen-Cahn equation*
	11:05-11:20	Ya-Chi Chu (National Cheng Kung University, M2) *The convexity for the joint range of two quadratic functions*
	11:20-11:25	Group Photo
13:00-13:55 **Session 3**		Chair: Shun Ito (Meiji University)
	13:00-13:15	Naoki Kondo (Meiji University, M2) *Mathematical modeling and analysis of filamentous active matter*
	13:15-13:30	Huan-Chi Chang (National Chung Cheng University, M3) *Using machine learning methods to predict RNA secondary structure*
	13:30-13:45	Koutaro Tanaka (Shimane University, M1) *Synchronous solutions and their stability in coupled salt-water oscillators*
	13:45-13:55	Yen-Jia Chen (National Center for Theoretical Sciences, B) *Mathematical models of COVID-19 with diffusion effects and their data forecast*

14:15-15:10 **Session 4**		Chair: Chih-Chiang Huang (National Taiwan University)
	14:15-14:30	Ryosuke Sakai (Meiji University, M2) *On Pehlivan's four-scroll chaotic system*
	14:30-14:45	Jin-Zhi Phoong (National Taiwan University, M2) *On synchronization analysis of complex coupled Kuramoto oscillators*
	14:45-15:00	Ryota Kubohara (Shimane University, M1) *Periodic solutions for three species Lotka-Volterra competitive equations*
	15:00-15:10	Jian-Yu Chen (National Central University, B) *Combine visual cryptography with RSA algorithm*
15:30-16:25 **Session 5**		Chair: Shun-Chieh Wang (National Taiwan University)
	15:30-15:45	Yuto Sakai (Ryukoku University, M1) *Comparison principle for time fractional diffusion equations*
	15:45-15:55	Yueh-Tzu Hung (National Yang Ming Chiao Tung University, B) *Turing instability for a class of 3-component systems*
	15:55-16:10	Yuto Kikuchi (Shimane University, M1) *A consideration of a difference on two types of mutual interactions between individuals in flocks with numerical simulation*
	16:10-16:25	Hao-Yuan Chang (National Cheng Kung University, M1) *Near rings and BIBD*

March 9 (Tuesday)

Below timetable is Taiwan time. Add 1 hour for Japanese side.

8:50-9:00 **Opening**		
9:00-10:00 **Session 6**		Chair: Pu Zhao Kow (National Taiwan University)
	9:00-9:15	Kazuya Okamoto (Musashino University, M2) *A nonlinear difference equation with bistability as a new traffic flow model*
	9:15-9:30	Chou- Kao (National Cheng Kung University, M2) *Semi-Lagrangian schemes for level set equation*
	9:30-9:45	Kazuhito Toyota (Future University Hakodate, M1) *Proposal and simulation of a reservoir computing by Belousov-Zhabotinsky reaction to generate a sine wave*
	9:45-10:00	Zhi-Hao Shi (National Taiwan University, M2) *Traveling wave solution for a stage structure model*
10:20-11:30 **Session 7**		Chair: Kazuki Shigyou (Hiroshima University)
	10:20-10:35	Tzu-Hsien Young (National Yang Ming Chiao Tung University, M2) *Detection of change points for Weibull distributed time series data*
	10:35-10:50	Ya-Chi Wang (National Yang Ming Chiao Tung University, M2) *Image inpainting algorithm based on partial differential equation approach*
	10:50-11:10	Yue-Hong Li (National Cheng Kung University, D1) *The asymptotic expansion of the trace of heat kernel on S2 under S1-action*
	11:10-11:30	Shun Ito (Meiji University, D1) *Control of spatio-temporal chaos of Ginzburg-Landau equation*
13:00-14:05 **Session 8**		Chair: Yu-Shuo Chen (Tamkang University)
	13:00-13:20	Pu-Zhao Kow (National Taiwan University, D3) *The Lewy-Stampacchia inequality for the fractional Laplacian and its application to anomalous unidirectional diffusion equations*
	13:20-13:40	Masakazu Kuze (Hiroshima University, D2) *Chemical oscillations and waves on microbead in Belousov-Zhabotinsky reaction*
	13:40-14:00	Kazuki Shigyou (Hiroshima University, PD) *Development of light field microscope for whole brain imaging of C. elegans*
	14:00-14:05	Group Photo
16:00-16:30 **Awards session**		

Lyapunov functions for some epidemic models with delay

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As far as the current situation, disease transmission is an important issue. Predictive mathematical models for epidemics are fundamental to understand if the disease will break out or die out. In this talk, we will focus on the global stability of the solution of various models, such as SIS, SEIR, SEIS, SIQR, and SEIQR models, with distribution delay based on the construction of various Lyapunov functions.

Mathematical Study on Hidden Emotions and Body Patterns Observed in Cuttlefish

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Cuttlefish has a high intelligence and visual ability, and can change "body pattern" rapidly, which includes body colors, patterns and textures. It has been suggested that this specific ability has a role not only as camouflage, but also as a communication tool [1]. Although their body patterns had been classified by visual confirmation [2], it is considered still insufficient because cuttlefish's body patterns are more variety and complicated than human eye can distinguish. The difficulty of classification makes it difficult for us to understand a regularity and a meaning of cuttlefish's body patterns in communication.

The purpose of this research is to figure out the communication system by body patterns in cuttlefish. In this research, we used the experimental data in a situation where two cuttlefishes seem to be communicating. For a classification in detail, we extracted a series of image data of the body patterns from the videos, and classified them 30 categories using machine learning (ML). Then, to estimate changes in emotion behind the body pattern expressed, we applied a Hidden Markov Model (HMM) to the time-series data on the categories of body patterns. In this presentation, we will discuss an emotion estimation of the cuttlefish based on psychological models, using the estimated results of HMM and the behavioral data.

References

[1] Hanlon, R. T. & Messenger, J. B. "*Cephalopod behaviour (2nd ed.)*", Cambridge University Press, Cambridge (2018)

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A Method to Infer Latent Dynamics Model by Combining Deep Neural Networks with Ensemble Kalman Filter

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Inference of latent dynamics model plays an important role in time-series analysis such as prediction, imputation, and control for time-series data. To infer the model, FIVO and its variants combine deep neural networks (DNNs) with sequential Monte Carlo (SMC) and provides the state-of-the-art predictive performance [1, 2]. However, these methods have mainly two weaknesses: less particle diversity and biased gradient estimates. The ensemble Kalman filter (EnKF) which is widely used in the meteorology has good characteristics to overcome these drawbacks. In our presentation, we will review the characteristics of the FIVO and discuss the applicability of the EnKF to infer the nonlinear dynamics.

References

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[2] A. K. Moretti, Z. Wang, L. Wu, I. Drori, and I. Pe'er. "Variational Objectives for Markovian Dynamics with Backwards Simulation", in European Conference on Artificial Intelligence, 2020.

The Data Forecast of COVID-19 by method of machine learning

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By using the data from US, South Korea, Brazil, India, Russia, Italy and also adjusted the related data parameters in numerical simulations to generate forecast and the effect of prediction of the epidemic situation for each country. Meanwhile to utilize US data to compare SQIARD with SIARD, and show the effects of predictions.

In this lecture, i will use mathematical models and data analysis methods to analyze the proportion of asymptomatic infections in various countries and predict the future trend of the epidemic. Then one of way is to rewrite the differential equations as discrete form with the consideration in [1]. Therefore, we establish two mathematical models, SQIARD and SIARD model, to simulate the COVID-19 epidemic. Obviously the SIARD model is only a simplified form of the SQIARD model. The difference between this two models are one include the parameters "number of people to be screened for the epidemic" and another one exclude it. It is very hard to get the data for this parameter but fortunately US government has complete data on the number of people in quarantine. This data can be used to generate the model parameters. In order to get the related model parameters, to remove the parameter $Q(t)$ first and then use SIARD model to conduct the prediction data of US, South Korea, Brazil, India, Russia and Italy. The prediction of the SIARD model will be created first and then use US's data which contains $Q(t)$ to show the effect of prediction of the SQIARD model.

Since the most serious epidemic of COVID-19 was in 2020, so we take training data: 5/11 $\sim$ 8/19 and validation data: 8/20 $\sim$ 9/8. After training our model, i use this model to predict future: 9/9 $\sim$ 9/28. Finally, i use this model on date: 1/11 to predict 1/11 $\sim$ 1/31, until on date 1/31, i can use the really data to compare the predict data obtained by our model.

References

[1] Yi-Cheng Chen, Ping-En Luy, Graduate Student Member, IEEE, Cheng-Shang Chang, Fellow, IEEE, and Tzu-Hsuan Liux. A Time-dependent SIR model for COVID-19 with Undetectable Infected Persons. *IEEE* (2020)

Why do two-dimensional dunes always merge?

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Sand dunes are mounds generated through the transport of sand caused by the wind. We focus on barchan dunes and transverse dunes, both of which are generated under the unidirectional flow condition. In the vertical cross-section along the flow direction, the barchan dunes and transverse dunes are simplified by a triangular object in two-dimensional space.

Dunes move and interact (one another). Barchan dunes, dunes with a three-dimensional crescent-like structure, show a variety of interactions; merging, splitting, and ejection, during the collision [1]. On the other hand, the transverse dunes, dunes with quasi two-dimensional structure, always merge during the collision [2]. Clearly, the difference of collision behavior comes from the detailed flow pattern depending on the detailed shape of the dunes, however, the mechanism has not been clarified.

In this study, we analyzed flow structure around two-dimensional dune models, triangular cross-sections, by direct numerical simulation. When two cross-sections are placed at particular intervals, a dead-water region was observed between them, where the flow velocity was much slower than that in the surrounding area (Fig. 1). Further we analyze sand transport based on the flow velocity distribution, which leads to the conclusion that two-dimensional dunes always merge [3].

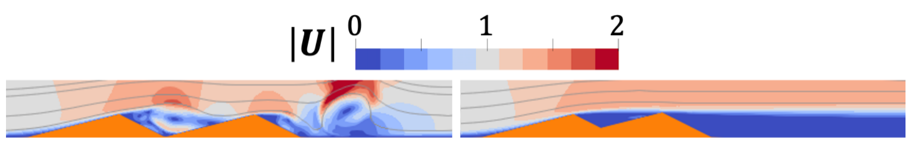

Figure 1: Snapshots of flow speed around dune models ($Re = 1000$). Height of model is $h = 1$. Left: peak-to-peak distance is $D = 6$. Vortices are generated from both tops of the dunes. Right: peak-to-peak distance is $D = 3.9$. Dead-water regions (blue) are observed between the dunes and downstream.

References

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The Second Laplacian Eigenvalue

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The second smallest normalized Laplacian eigenvalue is closely related to the connectivity of a graph. The Cheeger inequality states that graphs with a small second eigenvalue can be easily divided into two, and graphs with a large second eigenvalue are highly connected. In the presentation, I will show the application of graphs with a small second eigenvalue to image partition, and the application of graphs with a large second eigenvalue to computer networking.

Discontinuous steady states of the nonlocal Allen-Cahn equation

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Since Turing stated in 1953 that reaction diffusion equations exhibit complicated pattern due to the diffusion induced instability, a variety of reaction diffusion equations have been proposed and analyzed. There is much research about the structure of the solution of reaction diffusion equations, in particular, the Allen-Cahn equation. For example, Allen-Cahn equation has a travelling wave solution [2]. Moreover, the convexity of the domain is essential for the uniform solutions to be only stable steady states of the Allen-Cahn equation [5, 3].

Stable nonuniform steady states can appear in reaction diffusion equations with nonlocal effects, called nonlocal reaction diffusion equations. Bates and Chmaj analyzed the Allen-Cahn equation with nonlocal diffusion term defined by the convolution, and showed there exist stable and discontinuous steady states [1]. Kaliuzhyni-Verbovedsky and Medvedev in [4] formulated a nonlocal reaction-diffusion equation as

$$\frac{\partial u}{\partial t}(x,t) = D[Lu](x,t) + f(u(x,t)), \quad [Lu](x) = \int_0^1 W(x,y)u(y)dy - \left(\int_0^1 W(x,y)dy\right)u(x),$$

where W is a measurable function on $[0,1]^2$, f is a general function in $\mathbb{R}$ and $D > 0$. We call the equation the nonlocal Allen-Cahn equation if f is bistable.

There are two goals for this research. One is to show the existence of the stable and discontinuous steady states of the nonlocal Allen-Cahn equation. We also show numerical results, which imply the existence of such solutions even if the sufficient conditions do not hold. The second goal is to show the existence of the solution globally in time for a general function f by proving that the nonlocal operator L is a sectorial operator.

References

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The Convexity for The Joint Range of Two Quadratic Functions

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Given $n \times n$ symmetric matrices A and B, Dines in 1941 proved that the joint range set $\{(x^T Ax, x^T Bx)|\ x \in \mathbb{R}^n\}$ is always convex. Our work is concerned with non-homogeneous extension of the Dines theorem for the range set $\mathbf{R}(f, g) = \{(f(x), g(x)) \mid x \in \mathbb{R}^n\}$, $f(x) = x^T Ax + 2a^T x + a_0$ and $g(x) = x^T Bx + 2b^T x + b_0$. In this talk, we will illustrate that $\mathbf{R}(f, g)$ is convex if, and only if, any pair of level sets, $\{x \in \mathbb{R}^n | f(x) = \alpha\}$ and $\{x \in \mathbb{R}^n | g(x) = \beta\}$, do not separate each other. With the novel geometric concept about separation, we also provide a polynomial-time procedure to practically check whether a given $\mathbf{R}(f, g)$ is convex or not.

This is a joint work with Professors Huu-Quang Nguyen and Ruey-Lin Sheu.

Mathematical modeling and analysis of filamentous active matter

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Loosely defined, active matter refers to agents that displaying a function of self motion; such as the motion of flocks of birds, as well as camphor scrapings atop water. Motivated by experiments from S. Nakata et al. [1], we consider the following model equation:

$$\begin{cases} \tau u_t = \Delta u - u + \delta_\Gamma & t > 0, \gamma(t,s) \in \Gamma, (x,y) \in \mathbf{R}^2 \\ \dot{\gamma}(t,s) = -\nabla u(\gamma(t,s)) + F & t > 0, s \in [0, L(\gamma)), \gamma \in \mathbf{R}^2 \\ u(0,x,y) = 0 & (x,y) \in \mathbf{R}^2 \\ \lim\limits_{s \to L(\gamma)} \gamma(t,s) = \gamma(t,0) & t > 0 \\ \gamma(0,s) = \gamma_0(s) & s \in [0, L(\gamma)) \end{cases} \tag{1}$$

The above model includes a reaction-diffusion equation and a Newtonian equation for expressing the motion of filamentous active matter which causes the Marangoni convection. Given initial and boundary conditions, u denotes the concentration of a chemical substance within the domain $\mathbf{R}^2$, $\gamma(t,s) = (\gamma_1(t,s), \gamma_2(t,s))$ designates the shape of the active matter, δ_Γ is a delta function, $L(\gamma)$ is a length of Γ, $s \in (0, L(\gamma))$ is an arc-length parameter, $F(\Gamma)$ is an outer force acting on the active matter, and τ is a nonnegative constants.

In this talk, we will discuss the stability analysis of the model equation, using the method of adiabatic elimination. In particular, we derive analytic expressions for ring-shaped stationary solutions in terms modified Bessel functions and show the results of numerical simulations.

References

[1] S. Nakata, K. Kayahara, M. Kuze, E. Ginder, M. Nagayama, and H. Nishimori, Soft Matter, *Synchronization of self-propelled soft pendulums* 2018, **14**, pp. 3791–3798

Using machine learning methods to predict RNA secondary structure

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Machine learning has been widely used in many fields recently, including biological information. RNA plays an important role in the processes of genetic coding, translation, and gene expression. To understand the functionality of RNA, scientists need to know its secondary structure formed by the pairing of nucleotides. The structures can be obtained by biological experimental technology directly, however, our research intends to use machine learning methods to predict RNA secondary structure through Neural Network, Random Forest, Extreme Gradient Boosting (XGBoosting), LightGBM (Light Gradient Boosting Machine, LGBM), etc. Comparing the predicted results with the experimental laboratory structure, calculating the average prediction accuracy, and exploring the reasons for the poor cases, we try to find feasible correction methods to improve the accuracy of predicting RNA secondary structure by machine learning methods.

Synchronous solutions and their stability in coupled salt-water oscillators

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A salt-water oscillator is a vibration phenomenon in which salt-water outflow and water inflow occur alternately at regular intervals by placing a cup with a small hole in the bottom containing salt-water in a container filled with water. In this talk, we will present stability results on synchronous solutions in coupled salt-water oscillators where two salt-water oscillators are placed close to each other, expressed by following equations

$$\frac{d^2x_1}{dt^2} - \varepsilon\left\{\alpha - \beta\left(\frac{dx_1}{dt}\right)^2\right\}\frac{dx_1}{dt} + \omega^2 x_1 = \delta\left(a_{11}x_1 + a_{12}x_2 + b_{11}\frac{dx_1}{dt} + b_{12}\frac{dx_2}{dt}\right)$$

$$\frac{d^2x_2}{dt^2} - \varepsilon\left\{\alpha - \beta\left(\frac{dx_2}{dt}\right)^2\right\}\frac{dx_2}{dt} + \omega^2 x_2 = \delta\left(a_{21}x_1 + a_{22}x_2 + b_{21}\frac{dx_1}{dt} + b_{22}\frac{dx_2}{dt}\right)$$

where x_1, x_2 represent the height difference between water surface and salt-water surface, and $\alpha, \beta, \omega, \varepsilon, \delta$ are positive constants with $0 < \delta \ll \varepsilon \ll 1$. Our results include mathematically new findings not found in [1].

References

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Mathematical models of COVID-19 with diffusion effects and their data forecast

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In this paper, we introduced a SIARD model with diffusion. We discussed that there is a weak solution in the model, and then discussed the condition of basic reproduction number and disease free equilibrium of the model. Finally, we show the numerical simulation on SIARD diffusion model. After that, we train the related data parameters, in our numerical simulations, we respectively conduct the forecast of the data of US, South Korea, Brazil, India, Russia and Italy, and the effect of prediction of the epidemic situation in each country. Furthermore, we apply US data to compare SQIARD with SIARD, and display the effects of predictions.

On Pehlivan's four-scroll chaotic system

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Since 1970, chaotic dynamical system have been attracting attention from many researchers. Lorenz equation[1] is one of the typical example of such systems. It has a double-scroll chaotic attractor called the Lorenz attractor. In recent years, the subject of interest has shifted to the study of multi-scroll attractors, which have more complex topological structures. In fact, there have been reports about the existence of 2, 3 and 4 scroll attractors. Therefore, it is important to elucidate the structure of the chaotic attractor of such chaotic systems. The purpose of this paper is to discuss the dynamics of Pehlivan's model[2], which has a four-scroll attractor(see Figure 1) with a smooth function. It has been suggested by the previous research[3] that Pehlivan model has an invariable plane when b = 1 and its vector field affects the structure of the four-scroll attractor. This study focused on Pehlivan model when b=1. In this research, we revealed the dynamics when b = 1 and found the geometric structure of the attractor from the analysisby Poincare map when b is close to 1.

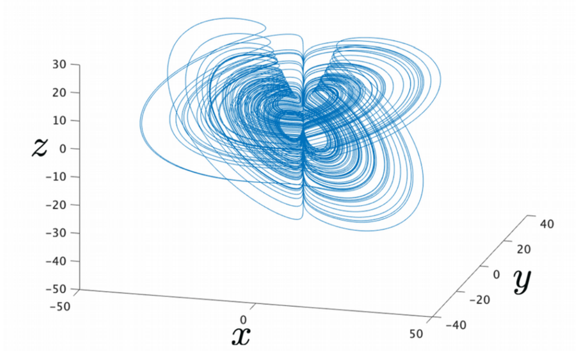

Figure 1: four-scroll attractor

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On Synchronization Analysis of Complex Coupled Kuramoto Oscillators

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This paper studies the synchronization problem emerging in a network of coupled oscillators which can be found in various natural phenomena. Here, the complex scenario has been considered. The sufficient condition for the frequency synchronization has been established for the uniform case.

Periodic Solutions for Three Species Lotka-Volterra Competitive Equations

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There have been many studies on three species Lotka-Volterra competitive systems

$$\begin{aligned} \frac{dX}{dt} &= (\varepsilon_1 - X - \beta_1' Y - r_1' Z)\, X \\ \frac{dY}{dt} &= (\varepsilon_2 - r_2' X - Y - \beta_2' Z)\, Y \\ \frac{dZ}{dt} &= (\varepsilon_3 - \beta_3' X - r_3' Y - Z)\, Z, \end{aligned} \tag{2}$$

where ε_i, β_i' and r_i' $(i = 1, 2, 3)$ are positive constants (for example, [1]). For the cyclic competition case $\beta_i' = 0$ $(i = 1, 2, 3)$, the existence of periodic solutions was proven by [2]. In this talk, we try to generalize the result to non-cyclic competition cases (2) by some new method making use of several quadratic curves.

References

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[2] H. Nakajima, Stability and periodicity for ecological system model (Japanese), *Busseikenkyu* **29**(6), pp. 345–387

Combine Visual Cryptography with RSA Algorithm

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In today's age of advanced Internet, when we send an important image to others, it is difficult to guarantee that it will be transmitted with security. Thus, the encryption of the image is very important. Traditional visual cryptography used to extend to the k out of n scheme where a secret image is encrypted into n shares but only k shares are needed for decryption where

$$k \leq n$$

However, this method often accompanied by image contrast reduction, and when putting it into computer, it might be cracked since it's density is not uniform. Thus, we construct a method to encrypt the image by combining with RSA Algorithm [1] . Thank to the fact that finding the factors of a large composite number is difficult, RSA Algorithm is still not easy to crack. By encrypting the pixels of the image by RSA Algorithm to increase the security of encryption, this method attain the result what we are expected.

References

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Comparison principle for time fractional diffusion equations

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Introduction

We consider the following a time fractional diffusion equation

$$\begin{cases} {}_0^cD_0^\alpha u = u_{xx} + f(u), & x \in \mathbb{R},\ t > 0, \\ u(x,0) = u_0(x) \geq 0, & x \in \mathbb{R}, \end{cases}$$

where $0 < \alpha < 1$ and ${}_0^cD_0^\alpha u$ is a Caputo derivative, which is defined as in

$${}_0^cD_0^\alpha u(x,t) := \frac{1}{\Gamma(1-\alpha)} \int_0^t (t-s)^{-\alpha} \frac{\partial u(x,s)}{\partial s} ds.$$

Here $f(u)$ is a globally lipschitz continuous function and u_0 is a continuous function. we will give a proof of the comparison principle for the time fractional diffusion equation. In order to prove it, we use the Mittag-Leffler function, which is one of generalization of exponential functions.

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Turing Instability for a Class of 3-component Systems

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We investigate the Turing instability for three-component systems with cross-diffusion. The main goal is to understand the effect of cross-diffusion on the stationary instability (S-instability) and wave stability (W-instability), respectively. Some sufficient and/or necessary conditions for Turing instability to occur are provided. Numerical simulations and applications are given to illustrate our theoretical results.

A consideration of a difference on two types of mutual interaction between individuals in flocks with numerical simulation

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A behavior of self-propelled particles with rules of mutual interactions, which is a model for a flock of organisms [1], is greatly affected by kinds of the rule of interactions. Previous study in a jackdaw flock has reported that there are two types of interactions [2]: "metric interaction" that takes the average of vectors in all particles which exist within a certain range, and "topological interaction" that takes the average of vectors in a specific number of particles. The former is considered to be used in a situation for avoiding predators, while the latter is used for group flight. These simple rules of interaction help us to understand a flock-like behavior, but careful studies are required when we consider a mechanism of real organisms' flock behavior. For example, it is not reasonable that in "metric interaction" individuals who exist slightly outside of the specified distance would not interact, and in "topological interaction" individuals would interact if it is exactly within the specified number. In addition, it seems to be difficult for organisms to switch adequately between two rules in response to a situation, so we consider to be unlikely that organisms have a specific number for interaction, and have multiple rules for interaction in their environment.

The purpose of this study is to suggest that an idea of a plausible interaction rule which realize both flock behaviors observed in metric and topological interactions. In this study, we will propose a new model of the interaction using flock's density: the smaller the density, the larger the distance over which the certain interact range. In this presentation, as a first step for building a model, numerical simulations with each model by two kinds of interactions are performed to verify each flock behavior and discuss the features of each interaction.

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Near rings and BIBD

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A right near ring is a triple $(N, +, *)$ where N is a set and $+$ and $*$ are binary operations on N such that

1. $(N, +)$ is a group (not necessarily ablelian);
2. multiplication is associative;
3. $(a + b)c = ac + bc$ for all $a, b, c \in N$;

I will introduce some interesting fact about near rings, and a special case called planar near rings. In 1968, Ferrero found a way to produce many examples of planner near rings, and we can produce balanced incomplete block designs (BIBDs) from them. BIBD is a subject in combinatory which applied in experimental design, so the result helps giving more examples. Moreover, we can design a code base on those block designs made by planar near rings.

A nonlinear difference equation with bistability as a new traffic flow model

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Macroscopic traffic flow models have the usefulness of reducing the cost of large-scale numerical simulation on traffic networks. This is because the macroscopic traffic flow model does not focus on each car in mathematically expressing the movement of the car, but on how dense the cars are in a lattice. By expressing this, it is not necessary to calculate the number of cars. In this session, we introduce a new macroscopic traffic flow model composed by the difference equation and linear analysis for it. This model is a reference model [1] with the past time added, which represents the inertia of the car. We show that the parameters of our model have the potential to eliminate traffic jams from the perspective of stability. It is understood that changes in average density change the stability of homogeneous flow, resulting in traffic jams. In other words, the homogeneous flow is stable when the average density is low, but when it exceeds the critical density, it becomes unstable and cannot be maintained, and transitions to inhomogeneous flow, which is observed as traffic jams. Actually, the conditions under which the homogeneous flow becomes unstable are derived from the linear stability analysis, and we consider the conditions under which traffic jams occur based on the unstable region. In addition, the phase diagram of the model was obtained using numerical simulation, and it was shown that the model has the property of bistability, which is very important in the traffic flow models [2]. Bistability is the property that two solutions are stable with respect to the same mean density. We explain that the model shows a density region where both homogeneous and inhomogeneous flows are stable. Then it shows numerically that the inhomogeneous flow is traveling in the opposite direction of the traveling direction of the car, like the traffic jams seen in the actual traffic flow.

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Semi-Lagrangian Schemes for Level Set Equation

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Semi-Lagrangian (SL) scheme is widely applied in computation of first order equation where the solution is discretized by Lagrangian formulation in time over a fixed grid in space. In this talk, I will discuss SL scheme for one dimensional scalar convection equation and Eikonal equation, where the solution curve moves in given velocity and in normal direction respectively. WENO scheme as a higher order interpolation will be mentioned. Then I will extend to SL approximation of level set equation in two dimensional space where a quasi-fifth order interpolation technique is proposed.

Proposal and simulation of a reservoir computing by Belousov-Zhabotinsky reaction to generate a sine wave

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The BZ(Belousov-Zhabotinsky) reaction is a chemical reaction in which the redox state changes slowly and cyclically. The BZ reaction is known to produce complex structures such as oscillatory rhythms, excitable patterns and chaos. It also has the property of changing its period under the influence of light stimulation. The BZ reaction is often used in experiments because it can represent complex chemical reaction systems with few reagents [1].

One of the recurrent neural networks that is well known as machine learning is a method called the "reservoir computing" [2]. It is often characterized by the use of physical phenomena in the reservoir laid in the middle layer of a machine learning. In the past, other researches of the reservoir computing have been implemented using a bucket of water or a soft material that resembles an octopus foot as a reservoir [3]. However, there have not been many implementations yet due to problems such as the time and effort required for preparation. Conversely, the BZ reaction can be easily experimented and various chemical reaction systems can be represented by adjusting the reagents. Therefore, in this study, we try to propose the reservoir computing driven by BZ reaction. We regard the BZ reaction as a reservoir.

We investigate whether it is theoretically and numerically possible to perform a reservoir computing by BZ reaction. We compute the partial differential equation model of the BZ reaction numerically in a two-dimensional domain and placed some units to distill the time series data on that domain. We assume that the target output is set as a sine wave, and the back projection from the output is given by the light stimulation in the model. Varying the parameter of strength for the light in the model as a sine wave, we verify whether to output a sine wave similar to the light stimulation by the linear sum of the time series of the units. As a result, it is found that the sine wave could be output roughly.

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Traveling wave solution for a stage structure model

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In the first part of this short talk, I will introduce some preliminary researches on a non-time-delayed two age stage structure model in mathematical ecology (in brief, stage structure model). Its characteristic is, different from the single stage model that uses a scalar function (or constant value) to represent its growth rate (or to say: fitness), the staged structure model uses a 2*2 matrix function (or constant matrix) to describe the succession of sub-populations in different life history stages of the total population. Many variants of this model were first modeled between the late 20th century to the beginning of the 21st century. Also, some studies of parabolic problems have been carried out since early 21st century, for example, classical papers are [1] [2] [3].

What's more, the minimum speed of the traveling wave fronts of this class of model was not determined until 2020 by Huang *et al.* [4] . Besides, the existence of the traveling wave and the linear determinancy of the wave velocity have not been further investigated. In the rest of this short talk, I will talk about some progress on the existence of the traveling wave solution of a special case based on the recent studies by Prof. Chen and me.

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Detection of Change Points for Weibull Distributed Time Series Data

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Wind power is a valuable sustainable energy that many countries have been agreesively developing. In energy resource assessments, understanding the regional wind properties is a crucial problem. A common way of the assessments is to model the wind speed data with a two-parameter Weibull distribution, in which the scale and shape parameter are estimated from the measurement data. This process succeeds when the data follow a unique specific Weibull distribution. However, if there are change points, at which the wind speed distribution changes, the changes in wind properties cause the statistical error margins in the energy resource assessments. To address the issue more accurately, one approach is to identify the change points and perform the assessments on the dissected sectional data. For this purpose, we propose to use the prune exact linear time algorithm [1], combining with detection of changes of Weibull distribution parameters. The PELT algorithm has an excellent linear complexity, $O(n)$, which is particularly suitable for large amount of time series data. The change point detection is based on the maximum-likelihood method. To demonstrate the method, we first construct thousands synthesized wind speed time series, containing two sets of Weibull distributions, i.e. with one deliberately added change point. The detection result indicates that the present method resolves the change points more accurately than the classical change point detection scheme with normal distributions. Finally, we apply the method to the real Fuhai offshore wind mast data, taken between 2017/11/18 and 2018/10/26. The present method identified two significant change points occurring on 2018/02/26 and 2018/09/23, and they agree precisely with the transitional periods between the winter and summer monsoon seasons in Taiwan.

This research is supported in parts under MOST, 109-2218-E-001 -003 and is a joint work with Professors Pi-Wen Tsai, Chih-Yu Kuo and Wen-Yi Chang.

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Image Inpainting Algorithm Based on Partial Differential Equation Approach

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In this talk, we numerically study the algorithms for image inpainting based on energy minimization and the low dimensional manifold. Li and Yao [1] have presented two mathematical models based on an energy function for image inpainting . Numerical schemes are introduced to solve the corresponding Euler-Lagrange equations. As for Low Dimensional Manifold Model (LDMM) which was studied for image processing in [2], LDMM uses the dimension of the patch manifold and the Euler-Lagrange equation is obtained by applying weighted nonlocal Laplacian (WNLL).

In this talk, numerical experiments are presented for removing the unwanted region by using Li-Yao model and LDMM ,respectively. This is a joint work with Professor Ming-Cheng Shiue.

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The Asymptotic Expansion of the Trace of Heat Kernel on $\mathbb{S}^2$ under $\mathbb{S}^1$-action

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Given a n-dimensional compact manifold M and a compact group G acting on M of isometries. We denote $\triangle$ the Laplacian on M and E_λ the eigenspace with respect to λ, an eigenvalue of $-\triangle$. Consider (ρ, V) a finite dimensional irreducible representation of G. Jochen Brüning and Ernst Heintze defined a function and show that in [2]

$$L_\rho(t) := \sum_{\lambda \geq 0} e^{-\lambda t} \mathrm{dimHom}_G(V, E_\lambda) \sim t^{\frac{-n}{2}} \sum_{j=0}^{\infty} a_j t^{\frac{j}{2}}, \qquad t \to 0^+$$

if G is of ranking 1.
In this talk, we restrict our attention on a specific case, $M = \mathbb{S}^2$ and $G = \mathbb{S}^1$ and introduce the method mentioned in [3] to achieve the coefficients of the expansion via studying the asymptotic expansion of the following double integral

$$\int_0^{\epsilon} \int_0^{f(\delta,y)} e^{\frac{-x^2y^2}{t}} x^\alpha y^\beta dxdy$$

As a result, we want to find how does the geometry information(e.g. metric) affect on the coefficients a_j in $L_\rho(t)$.

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Control of spatio-temporal chaos of Ginzburg-Landau equation

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Ginzburg-Landau equation has two types-behavior: one is spatio-temporal chaos, the other is a limit cycle oscillation that is a spatially uniform periodic solution. Spatio-temporal chaos is located to near a fixed point inside a limit cycle on phase space. We numerically discovered that spatio-temporal chaos shifted to an outside of a limit cycle by a perturbation like a short time impulse converges on a limit cycle oscillation. Then, we prove analytically that an initial condition at an outside of limit cycle converges on a limit cycle oscillation.

The Lewy-Stampacchia Inequality for the Fractional Laplacian and Its Application to Anomalous Unidirectional Diffusion Equations

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We consider a Lewy-Stampacchia-type inequality for the fractional Laplacian on a bounded domain in Euclidean space. Using this inequality, we can show the well-posedness of fractional-type anomalous unidirectional diffusion equations. This study is an extension of the work by Akagi-Kimura (2019) for the standard Laplacian. However, there exist several difficulties due to the nonlocal feature of the fractional Laplacian. We overcome those difficulties employing the Caffarelli-Silvestre extension of the fractional Laplacian.

This talk is prepared based on [1], which is a joint work with Masato Kimura.

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Chemical oscillations and waves on microbead in Belousov-Zhabotinsky reaction

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The Belousov−Zhabotinsky (BZ) reaction, which self-organizes spatio-temporal patterns based on the autocatalytic reaction, is a widely studied experimental system. The metal catalyst of the BZ reaction was loaded into a cation-exchange resin bead. We call this bead the BZ bead. Global oscillations (GO), which are the uniform oscillations in the entire bead, and traveling waves (TW), which are the propagating chemical waves from one end of the bead, were observed when BZ bead was immersed into a BZ solution without a catalyst (Fig. 1a).[1] Previous study has reported that GO and TW could be selectively and reversibly generated by positive and negative values of the electrical potential, *E*, respectively. In this study, we found the hysteresis on the switching of the spatio-temporal patterns depending on the scanning direction of *E*. In addition, we discuss our results in the context of an increased concentrations of the activator, $HBrO_2$, or the inhibitor, Br^-, to clarify the mechanism of switching between GO and TW.

The switching from GO to TW occurred near –0.2 V in negative scan, i.e., from *E* = +1.0 V to −1.0 V (Fig. 1b). On the other hand, when *E* was scanned from −1.0 V to +1.0 V (positive scan), the switching from TW to GO occurred near +0.2 V. In the negative scan, GO were maintained because oscillations in the bead were strongly affected by sufficient concentration of the inhibitor which accumulated near the positive electrode. On the other hand, TW was maintained at a small value of *E* due to the electrochemical production of the activator in the positive scan.

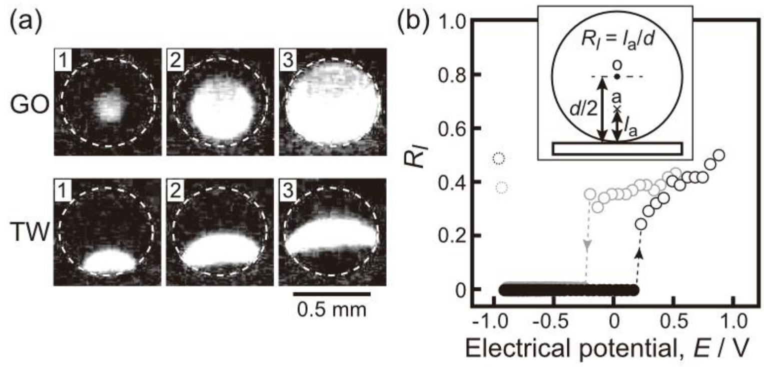

Figure 1. (a) Snapshots of GO and TW for the single bead. Dotted circles correspond to the edges of the beads. Time interval: 2 s. (b) The generation point of the oscillations, R_l, at d = 0.63 mm of the BZ beads at the scanning of the electrical potential (E). Gray and black circles correspond to the negative and positive scan, respectively.

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Development of Light field microscope for whole brain imaging of *C. elegans*

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Living organisms with nervous systems perform very sophisticated information processing, despite the fact that their brain volume is much smaller than that of latest computing units. For example, flies can instantly identify the spatial information of an oncoming human hand and, through fast feedback processing, can switch to avoidance behavior faster than humans can catch them [1]. In addition, even *Caenorhabditis elegans* (nematode), which have only 302 neurons, 1 mm long, and 50 to 100 m thick can memorize temperature [2] and odor, and dynamically change their behavior based on these memories. If these brain functions can be implemented as a device, it will contribute to realizing high-speed collision avoidance systems in cars and the development of advanced odor sensors. In order to understand and apply these function of the brain, we need to observe and quantify the whole brain activity. However, the time scale of the neural activity is milli-second order and the spatial scale is micro-meter to centi-meter scale with a complex 3D structure. Activities of the nervous system are difficult to observe with conventional observation equipment such as a confocal scanning laser microscope, because it has not enough temporal resolution. To solve this problem, Light field microscopes were developed by Leboy group in 2006 [3]. Light field microscopes can capture a three-dimensional structure in a single camera shot. Although this makes it possible to capture these 3D structures and nervous activity on milli-second order limited by camera frame rate, the spatial resolution of conventional light field microscopy is not enough to observe neural cells. Therefore, we developed a high-spatial resolution light field microscope. In this presentation, we will explain the principle of light field microscopes and observation results of the microscope we developed.

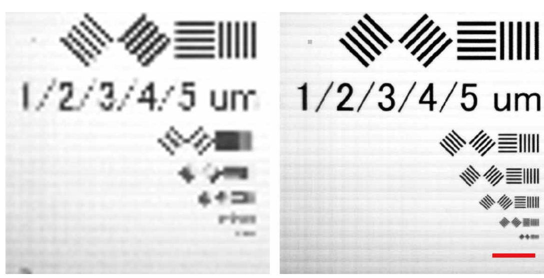

Figure 1: Conventional light field microscope image(Left). Our result(Right). Red scale bar is 100um.

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