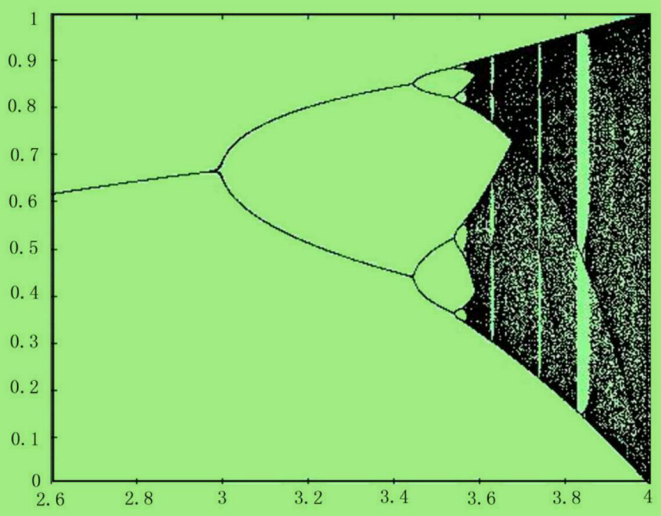
2007'

4th International Conference on Mathematical Biology

Abstracts



Wuyishan Fujian P.R. China

May 29 - June 1, 2007

4th International Conference on Mathematical Biology

Abstracts

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May 29 - June 1, 2007

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PREFACE

It is a very great pleasure for me to welcome the delegates to 4th ICMB 2007, the 4th international conference of mathematical biology, sponsored by the Chinese Society of Mathematical Biology(CSMB). The conference runs from 29 May-1 June 2007 at the Baodao Hotel in Wuyishan, China. The conference is very well attended, with over 380 experts and students participating from about 23 countries and regions. Nearly 200 abstracts of talks were submitted. Each paper will be blind reviewed by reviewers, and the assignment and reviewing process was overseen by the Chairs. The final acceptance submissions will be published by the Rocky Mountain Journal of Mathematics and Volume 9 in the World Scientific Book Series in Mathematical Biology and Medicine.

When I invited my colleagues and friends to come to the first ICMB we could not envisage that there was so rapid and diverse development of mathematical biology. The first ICMB was held in Xi' an 1988 as a prelude of research work of mathematical biology in China. We have successively held three conferences such that the collegial atmosphere is provided for the scientific discussion of the latest advances with the world' s leading experts in the field of mathematical biology and development of China' s mathematical biology is accelerated and expanded. To maintain a good growth, there is plan to hold this conference on a five-yearly basis. We hope that more and more foreign experts will choose to attend our ICMB in order to present their most recent work.

At present, the CSMB has more than 300 member representatives from many universities and academic institutions of each province and district in China. Journal of Biomathematics, which is published by the CSMB from 1986 to now, is regarded as the most influential academic journal in the discipline of mathematical biology in China. It is our pleasure to inform

all delegates that Journal of Biomathematics Ser.B will be published by World Scientific Publishing.

It was a pleasure to serve as the chair of the conference and I can honestly say that it has been a memorable and rewarding experience. I would like to take this opportunity to thank all members of the CSMB for their conscientious effort, and every expert who help to put together a great conference and accelerate development of China's mathematical biology.

I am very grateful to:

Minnan Sci. and Tech. Institute, Fujian Normal University,

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Chinese Mathematical Society

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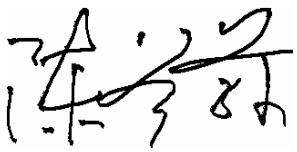
Finally I would like to thank my fiends for their sincere support:(sorted by alphabet of last name)

Carlos Castillo-Chavez, Jim M. Cushing, Odo Diekmann, Ying-Hen Hsieh, Sze-Bi Hsu, Yoh Iwasa, Yang Kuang, Simon Levin, Philip Maini, Avidan U. Neumann, Shigui Ruan, Karl Sigmund, Hal L. Smith, Jianhong Wu, Xiaoqiang Zhao, Huaiping Zhu.

It is my hope that this meeting will be as fruitful, profitable, and enjoyable for all delegates as the previous meetings proved have been.

May 6, 2007



Lansun Chen

Scientific Chairman, The Forth ICMB 2007
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DISEASE DYNAMICS ON NETWORKS

MURRAY E. ALEXANDER

Traditional epidemic models assume that infected individuals can uniformly spread the infection across a population. Representing individuals as nodes of a network and contacts between them as edges between nodes, provides a much more realistic model of disease spreading. The network structure is defined by the demographics of the population. By analyzing the structural properties and dynamics of these networks, one gains valuable insights into conditions for spreading of a disease and methods for their control. Many types of networks - for example, the Internet, social networks, sexual contacts, and food webs - exhibit highly heterogeneous distribution P_k of the degrees of their nodes, closely approximating a Scale Free Network (SFN): $P_k \sim k^{-\gamma}$. The spreading rate depends on the variance in this distribution, whereas in traditional epidemic models spreading rate is proportional to the number of contacts per individual, which is the same for all individuals. An epidemic outbreak coincides with the appearance of a giant component, which can be predicted from the structure of the network. The crucial point is that, for SFNs, the fluctuations - and hence the epidemic spreading rate - increase without bound as the network size increases. Theoretical network models provide a "correspondence check" for the highly complex individual-based models - built on very large databases of detailed demographic data. They also provide useful comparisons against simple, well-understood homogeneous models. Community structures (derived from actual demographic data) can easily be incorporated into network models, and insights gained by analyzing the structure and dynamics of these networks.

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Key words and phrases. Epidemic models, network dynamics, percolation theory, phase transitions.

THE ROLE OF ECOLOGICAL MODELING IN RESTORATION OF THE FLORIDA EVERGLADES

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ABSTRACT

The everglades of Florida, USA, is a mosaic of urban, agricultural, marsh and forest habitats in a vast neotropical wetland, with a pattern that has been altered by water management vie canals, levees, and water control structures. The Everglades system is a countless interconnected system of rivers, creeks, lakes, marshes, prairies, forests and estuaries.

The Everglades is often referred to as a marsh, a wetland, a region, a river, a watershed, an ecosystem. In hydrologic terms, the everglades is a watershed – a land area that delivers runoff water, sediment and dissolved substances to a major river and its tributaries.

South Florida is facing series challenges due to the rapidly increasing population and the increasing awareness of the unique ecosystem in the area. (e.g. Everglades).

To provide decision makers and water managers with objective , high quality advice on scientific and engineering issues pertaining to understanding, preserving and restoring the fauna and flora of the Everglades ecosystem, a management strategies need to be planned. in the process of developing management strategies for long-term protection and restoration of the Florida Everglades ecosystem, there is a clear need for a "predictive" methodology to allow evaluation of future water quality responses under alternative management scenarios. mathematical models are widely accepted as providing the means to evaluate such response. a key advantage of numerical models is their ability to delineate the cause-end-effect relationships, allowing the environmental manager to identify, target, and control problem sources by location and magnitude.

in this paper, a critical review on some ecological modeling efforts on the Everglades restoration in recent years. Many organizations and programs are dependent on scientific knowledge and more accurate models for restoring the Everglades ecosystem. these includes federal, state, and local agencies,Native American tribal government, as well as private organization.

some major models including the US Geological Surveys' (USGS) Across Trophic Level System Simulation (ATLSS) which provides models for assessing effects of greater Everglades restoration hydrologic scenarios on indicator species and key biotic components. Further, the Everglades Landscape Model (ELM) which is a regional-scale, integrated ecological assessment tool designed to understand and predict the landscape response to differ water management scenarios in south Florida.

A smaller scale models such as efish, which study the effect of hydroperiods on the fish population in the Everglades. Other ecological models which study the effect of toxicant (such as PCB's & Mercury) on the aquatic ecosystem are reviewed.

A mechanism for morphogen-controlled domain growth

Ruth E. Baker* and Philip K. Maini†

Growth is a fundamental aspect of development: it results from a tightly regulated combination of processes including cell differentiation, division and movement. Recent experimental studies have highlighted the role of a morphogen (Dpp) in controlling domain growth in the Drosophila wing. We model this phenomenon using a system of reaction-diffusion equations with advection. Analysis is carried out using a Lagrangian based approach and results show how uniform growth across the wing may be achieved.

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Effect of Age-Based Vaccination Policy on the Dynamics of Delay Epidemic Model

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Abstract : The spread of communicable diseases depend on rate of transmission or contact rate , removal rate , mode of transmission , latent and incubation period , age – specific susceptibility and immunity of individuals to the disease . The immunity to the specific disease in the individuals can be artificially developed with the help of vaccination . It is understood that the vaccination leads to complete protection and vaccinated individuals are immune but this is not true and in general vaccination only leads to partial protection . The role of latent period in the dynamics of communicable diseases is also an important factor and should be considered in the epidemic models . Further , while studying age-structured epidemic models, maturation period should also be considered in the model, because in the case of several infectious diseases the populations of certain Age – groups are immune from diseases for some finite period and after that they become susceptible .

In view of the above , therefore , in this paper a delay epidemic model has been studied to investigate the effect of age – based vaccination policy on the dynamics of a communicable disease incorporating latent period and maturation delay . For the model , the disease- free and endemic equilibrium points have been obtained and their local and global stability analysis have been carried out .

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MUTUALISTIC NETWORKS: THE ARCHITECTURE OF BIODIVERSITY

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The mutualistic interactions between plants and the animals that pollinate them or disperse their fruits have molded the organization of Earths's biodiversity. These interactions can form complex networks involving dozens and even hundreds of species. Recently, it has been shown that mutualistic networks are very heterogeneous, nested and build upon weak and asymmetric links among species. These network patterns have far-reaching consequences for species persistence and coevolution, and thus can be regarded as the architecture of biodiversity. Past evolutionary history conveyed in the phylogenies of both plants and animals contribute to shaping these coevolutionary networks.

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EVOLUTION OF MATURATION SIZE IN HARVESTED PREDATOR-PREY SYSTEMS

JAN JAAP POOS, ÅKE BRÄNNSTRÖM, AND ULF DIECKMANN

The potential of modern fisheries to induce adaptive changes in exploited stocks is now increasingly recognized. While early studies predicted that elevated mortalities among larger individuals select for reduced maturation size, recent theoretical studies have shown conditions under which other, more complex, evolutionary responses to size-selective mortality are expected. These predictions are based on the assumption that, owing to the trade-off between growth and reproduction, early maturation implies reduced growth. In this talk we critically evaluate and extend these findings by introducing a size-structured model of a harvested predator-prey community in continuous time, in order to explore the evolution of maturation size under all three traditionally acknowledged costs of early maturation: reduced growth, increased mortality, and reduced fecundity.

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Key words and phrases. evolution, adaptive dynamics, fisheries, early maturation.

The dynamics of a host-parasitoid model concerning slug control

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Abstract. In this paper, a host-parasitoid model is established concerning efficacious biocontrol strategies for dominant, agriculturally damaging slug species using naturally occurring parasitic nematodes. By using the persistence theory for infinite dimensional systems, the sufficient conditions for the permanence of the system are obtained. By constructing suitable Lyapunov functions and using an iterative technique, a set of easily verifiable sufficient conditions is also obtained for the local asymptotic stability and the global attractiveness of the positive equilibrium of the model.

Keywords. Slug biocontrol; parasitic nematodes; delay; permanence; global stability.
2000 Mathematics Subject Classification: 92D30; 34D23.

”Mathematical and biological consequences of aggregative behavior near habitat boundaries”

Robert Stephen Cantrell
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ABSTRACT

In this talk we consider the effects of nonlinear boundary conditions on a diffusive logistic equation in a bounded domain. The equation arises as a model for a population that grows logistically inside a focal patch of habitat and crosses the boundary at a rate that depends on the population density. Specifically, the rate at which the population crosses the boundary is assumed to decrease as the density of the population increases. The model is motivated by empirical work on the Glanville fritillary butterfly. In the first part of this talk we establish that for some ranges of parameters the model can support an Allee effect at the scale of the habitat patch. In the second we explore the local and global bifurcation structure of the problem. This work is joint with Chris Cosner and Salome Martinez.

”Mathematical and biological consequences of aggregative behavior near habitat boundaries”

Robert Stephen Cantrell
The University of Miami
（EMAIL：rsc@math.miami.edu）

ABSTRACT：
In this talk we consider the effects of nonlinear boundary conditions on a diffusive logistic equation in a bounded domain. The equation arises as a model for a population that grows logistically inside a focal patch of habitat and crosses the boundary at a rate that depends on the population density. Specifically, the rate at which the population crosses the boundary is assumed to decrease as the density of the population increases. The model is motivated by empirical work on the Glanville fritillary butterfly. In the first part of this talk we establish that for some ranges of parameters the model can support an Allee effect at the scale of the habitat patch. In the second we explore the local and global bifurcation structure of the problem. This work is joint with Chris Cosner and Salome Martinez.

Role of toxin producing phytoplankton on plankton dynamics - model based study with experimental support

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Abstract

Plankton dynamics is a fascinating and interesting subject of research. Plankton do a great deal of service for our earth-food for marine life, oxygen for human beings and also absorb half of carbon-di-oxide from the earth atmosphere. Bloom formation and plankton paradox are the ever green problems still now. Quite a good number of studies have been already appeared in the literature to explain the bloom phenomena and also for the solution of plankton paradox.

For the last ten years we are collecting marine samples from the west coast of Bay of Bengal to observe the diversity of phytoplankton and zooplankton species. We have already identified 14 phytoplankton species which are known as toxin producing phytoplankton (TPP). The role of TPP on the solution of plankton paradox and planktonic blooms has not received much attention by the scientific community. In this talk I shall focus these issues with the help of mathematical models and experimental findings. These observations will indicate that TPP is a potential candidate for a possible resolution on those issues.

The Judgment of Focus or Center for a Class of Higher Order Nonlinear Systems

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（Department of Mathematics & Physics, Anhui University of Technology, Ma'anshan, Anhui 243002, P R China）

Abstract

In the paper, the judgment of higher order focus or the center for a class of nonlinear systems:

$$\begin{cases} \dot{x} = -2x^2y - y^3 + x^3y^2 f(x,y) \\ \dot{y} = x^3 + x^2y^3 f(x,y) \end{cases}, \partial f(x,y) \geq 1$$

are discussed. Wherein $f(x,y)$ is an analytic function in some neighborhood of the original point with the assumption $f(0,0)=0$, so the original point is the singular point for the system. The stated systems arise frequently in many applied areas which include biomathematics, fluid dynamics, quantum mechanics, chemical reaction and so on. $f(x,y)$ being analytic in some neighborhood of the original point, we know that the singular point maybe a center point or a focus, thus the judgment problems for focus and center are performed. The conventional methods for the judgment of focus and center are the methods of successive function and the formal series. The judgment for focus and center is not only a important research direction in mathematical analysis, but also has osculating relationship to the stability of the system. The method which judges the focus and center can be applied to analysis the stability of the system. In the paper, the center and focus of a class of nonlinear system are analyzed, the efficient method for judgment is given, and the calculating formula for the focus value is obtained. At the end, a seven-degree system is stated as an example, its singular point is judged as a fine focus, and the system is simulated numerically and the conclusion is thus proved.

Keywords: focus and center focus value a seven-degree system
AMS(2000)Subject Classifications: 34C05 34C07

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Biography ： CHEN Song-lin (1964-),Professor, Major in nonlinear analysis
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Alignment of Signaling Pathways

Ming Chen[1], Gennian Ge[2]

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Research on alignment of gene and protein sequences has been intensively conducted in the past decade. Today, the exponential growth of biological databases arising from the results of high throughput experiments have paved a way to understand better how proteins and pathways interact with each other. Efforts are shifting to systems biology; investigation of biological pathways is becoming hot. A good number of databases like UNIPROT, DIP, BIND,KEGG etc., have lots of information about the proteins and pathways. But these databases give information about an individual protein, pathway or set of proteins or pathways in particular. The question is how better we can utilize the valuable information to broaden our knowledge on protein and pathways further. At one end tools are developed for the prediction of pathways and for network alignment and comparing protein interaction networks across species (Kelley et al.) and also to integrate the databases. But more than prediction and integration, the alignment of pathways is important and informative. Several approaches have been made to align metabolic pathways. A few of tools have developed to align the metabolic pathways (Chen et al., Printer et al.). One such tool is Pathaligner that is helpful in aligning metabolic pathways based on the enzyme classification number (Chen et al.). However, it is restricted to linear metabolic pathways. Less is done in the field of signaling pathways, which are equally important to the metabolic pathways that play a key role from cell birth to cell death. We would like to address this problem by expanding Pathaligner further and utilizing STCDB (Chen et al.) for the alignment of signaling pathways. Also we would like to incorporate the information from the available databases.

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Global Attractor of a Generalized Ginzbur-Landan Models For Reaction Diffusion Equation in Population Problems

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In this paper, the authors study a sufficient condition of global attractor in suite condition by operator semi-groups methods for a class of Ginzbur-Ladan models equations with more general nonlinear term in population problems for initial-boundary value problem .

Four periodic solutions of a generalized delayed predator-prey system on Time Scales *

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Abstract With the help of a continuation theorem based on Gaines and Mawhin's coincidence degree, easily verifiable criteria are established for the existence of four positive periodic solutions of a a generalized delayed predator-prey system on Time Scales.

Keywords time scales, four positive periodic solutions, delay, predator-prey system, coincidence degree
MR(2000)Subject Classification 34K15, 34C25, 34K20, 92D25

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OSCILLATION OF BOUNDED SOLUTION OF SECOND ORDER DIFFERENTIAL EQUATION WITH IMPULSIVE

CHENG JINFA

Sufficient and necessary conditions are established for the oscillation of bounded solution of the second order differential equations with impulsive

$$x''(t) - qx(t - \quad) = 0, t \neq t_k,$$
$$\Delta x'(t_k) - q_0 x(t_k - \quad) = 0.$$

where $q, q_0, \quad > 0, \Delta x'(t_k) = x'(t_k^+) - x'(t_k)$.

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The Mean of prediction sum of square as a criterion for selecting predictor variable

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ABSTRACT：. Variable selection is a necessary step in practical regression analyses. The prediction sum of squares (PRESS) criterion is an important criterion for selecting predictor variable in multiple regression. Although PRESS is based on prediction precision, the point is not used in establishing regression equation when the prediction error on this point is calculated. Therefore, it apparently emphasizes prediction effect and can be used to get the optimal argument set. We have not found further discussion as regards the distribution of PRESS and the feasibility of PRESS criterion.

COMPARATIVE ESTIMATION OF THE REPRODUCTION NUMBER FOR PANDEMIC INFLUENZA FROM DAILY CASE NOTIFICATION DATA

GERARDO CHOWELL, HIROSHI NISHIURA,
AND LUIS M.A. BETTENCOURT

Recurrent epidemics of influenza are observed seasonally around the world with considerable health and economic consequences. Major changes in the influenza virus composition through antigenic shifts can give rise to pandemics. The influenza pandemic of 1918 was responsible for at least 20-100 million deaths worldwide. The reproduction number, R, defined as the average number of secondary cases generated by a primary case, is a crucial quantity for identifying the intensity of interventions required to control an epidemic. We estimated the reproduction number using the daily case notification during the fall wave of the influenza pandemic (Spanish flu) in the city of San Francisco, California, from 1918-19. In order to elucidate the effects from adopting different estimation approaches four different methods are used. Our analysis indicates that the reproduction number for pandemic influenza, aggregated at the level of San Francisco, lies in the range of 2.0 to 3.0. Our estimates of the reproduction number for pandemic influenza strongly suggest a tighter range of uncertainty than has previously been assumed, as well as targets for public health interventions in the case of future similar pandemics that while very challenging may not be impossible to tackle.

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Key words and phrases. Differential equations; Spanish flu; Pandemic; Reproduction number.

Mathematical Aspects of the Ideal Free Distribution

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Abstract

The ideal free distribution as formulated by Fretwell and Lucas is a description of the equilibrium spatial distribution of a population that would arise if each individual were able to move to the location where its fitness is highest. Usually the presence of other individuals at a given location is assumed to reduce the fitness of each individual at that location because of crowding effects. This typically results in a situation where all individuals have the same fitness since if some individuals had a lower fitness than others they would move to increase their fitness. This talk will describe some recent work aimed at connecting these ideas to population dynamics. Specific aspects of this work include formulating the ideal free distribution in continuous space, deriving a partial differential equation which can produce that continuum version of the ideal free distribution as an equilibrium, making connections between the ideal free distribution and the idea of balanced dispersal, and showing that ideal free, i.e. balanced, dispersal strategies are sometimes evolutionarily stable in discrete diffusion models.

Dynamical model of infectious disease with media impact

Jingan Cui[1] .

We develop a three dimensional compartmental model to explore the impact of media coverage to the spread and control of infectious disease. The model may exhibit up to three equilibria: two disease free equilibria and a unique endemic equilibrium. Stability analysis of the model shows that the non-zero disease-free equilibrium is globally-asymptotically stable if a certain threshold quantity, reproduction number(R_0), which depends solely on parameters, is less than unity. On the other hand, if $R_0 > 1$ it is shown that a unique endemic equilibrium appears and a Hopf bifurcation can occur which causes oscillatory phenomena. Numerical simulations suggests that when $R_0 > 1$ and the media is strong enough, the model exhibits multiple positive equilibria which poses challenge to control and predict of infectious disease.

This talk is based on joint work with Yonghong Sun and Huaiping Zhu.

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Study of a Carrier Dependent Infectious Disease-Cholera

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Abstract

This paper analyzes an epidemic model for carrier dependent infectious disease - cholera. Existence criteria of carrier-free equilibrium point and endemic equilibrium point (unique or multiple) are discussed. Some threshold conditions are derived for which disease-free, carrier-free as well as endemic equilibrium become locally stable. Further global stability criteria of the carrier-free equilibrium and endemic equilibrium are achieved. Conditions for survival of all populations are also determined. Lastly numerical simulations are performed to validate the results obtained. Hope for your necessary action in this regard and oblige. With regards, Sincerely yours, Prasenjit Das

Parametric Conditions for Artificial Neural Network Model to Hold Short Term Memory

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Key Words: Short term memory (STM), ANN model, differential equation, attarctor.

Abstract:

Memory is one of the most complex basic system of the brain. Numerous studies have sown that the structure of human memory is not as simple as that of computers. Several dichotomies have been proposed to separate human memory systems according to the kind of information and processes they support: short term memory (STM) and long term memory, episodic and semantic memory, procedural and declarative memory etc.

In this paper, we like address the number of STM in the context of Artificial Neural Network (ANN) in particular. It was established the number of STM we can bear is seven with allowed variation of two. Long way after that, many researchers investigated the STM which takes place in the neocortex region of our brain. Particularly, a statistical mechanics of neocortical interactions (SMNI) has been developed to address mesoscopic phenomena in the human neocortex. The basic approach of the SMNI has been to statistically aggregate synaptic and neuronal interactions. The theory has been tested by verifying observations at the mesoscopic scale, e.g., short term-memory phenomena and at the macroscopic scale, e.g., electroencephalography (EEG) . SMNI addresses the 7? rule as the number of attractors possible in minicolumnar interactions, using synaptic and neuronal parameters taken from experimental data. This defines a probability distribution of firing activity, which can be used to further investigate the existence of other nonlinear phenomena, e.g., bifurcation or chaotic behavior, in brain states. Although, it can be debated that how 'short' is STM; or even the role of neocortex to hold STM. Working memory (WM), used as a substitute of STM is however, is not a hallmark of higher vertebrates endowed with a neocortex. STM is observed to transpire on the order of tenths of a second to seconds. Here we will investigate this 7? rule with the help of a general ANN model. In our earlier works, it was shown that these models of neural network given by three ordinary differential equations showed stable, periodic and chaotic behaviors which are common to human brain functioning. We have been working with ANN models that describes some of the properties of brain. It was found that these models of neural network given by 3 ordinary differential equations showed stable, periodic and chaotic behaviors which are common to human brain functioning. Particularly interesting aspect of the study was how a chaotic system can be brought back to stable state by tinkering appropriate parameters. Here we will consider a simplified two dimensional model to investigate the number of attractors (in other words, memory) that the system contains. We find conditions under which this model can show number of neocortical STM capacities.

The Picrad Contraction Mapping Method for Parameter Inversion of Reaction-Diffusion System

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Abstract

An inverse problem is to determine unknown causes based on observation of their effects. Such problems often arise in scientific research and ecology engineering practice. In this paper we present an extension of the Picard contraction mapping method(PCMM) for a class of inverse problems of ordinary differential equations to that of reaction-diffusion systems. We first modify the theoretical setting of PCMM so that it covers the method for solving reaction-diffusion system. For this purpose, we describe a general form of reaction-diffusion system in Sobolev spaces $H[[t_0, T], C^2(\Omega)]$, and introduce an approximate differential model which corresponds to the given reaction-diffusion system, and discuss contractivity of the Picard mapping associated with the approximate model. Then we present an algorithm for recovering parameters of reaction-diffusion based on Collage theorem. Theoretical analysis and numerical tests show that the presented method is efficient.

keyword parameter inversion, reaction-diffusion system, contraction mapping, Collage theorem.

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Persistence of vertically transmitted parasite strains which protect against more virulent horizontally transmitted strains

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Abstract

The question whether a vertically and a horizontally transmitted parasite strain can coexist under complete cross protection is investigated in a host-parasite model with susceptibles and infectives only. It is shown that coexistence is possible even if the vertically transmitted strain would go extinct on its own provided that it is considerably less virulent than the horizontally transmitted strain. While the vertical transmitted strain is without benefit to the host as such, it protects the host against the more harmful horizontally transmitted strain. The coexistence is shown in the form of uniform strong persistence of the host and both parasite strains.

Positive periodic solution for a Gause-type ratio-dependent predator-prey system with diffusion and time delay

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Abstract

A two-species Gause-type ratio-dependent predator-prey system with time delay in a two-patch environment is investigated. By using a continuation theorem based on coincidence degree theory, we establish easily verifiable criteria for the existence of periodic solution for the system. As corollaries, some applications are listed. In particular, our results extend and improve some known results.

MSC: 34K15; 92D25; 34C25.

Key words: Predator-prey system; Ratio-dependent; Diffusion; Periodic solution; Coincidence degree.

STABILITY OF A CHEMOSTAT MODEL WITH INHIBITORY EXPONENTIAL SUBSTRATE UPTAKE AND TIME DELAYS

QINGLAI DONG AND WANBIAO MA

The Chemostat dynamical model, which may be viewed as a laboratory model of a simple lake with continuous stirring, is of both ecological and mathematical interest since it is the most simple idealization of a biological system where the mathematics is tractable, the parameters are measurable, and the experiments are reasonable (H.L. Smith and P. Waltman, *The Theory of the Chemostat: Dynamics of Microbial Competition*, Cambridge, Cambridge University Press, 1994, and Nihon Hyolonsya (in Japanese), Y. Takeuchi (Eds.), Tokyo, 2004); L. Chen and J. Chen, *Nonlinear Biology Dynamics*, Beijing, Science Press, 1993). The studies of the Chemostat dynamical models with or without time delays and their experimental verifications of the match between theory and experiments have received a great deal of attention. Many modifications such as incorporating competition, food chain, periodic input and output etc are performed to describe the phenomena vividly. The studies include stability, the existence of the periodic solutions, persistence, competitive exclusion and bifurcations etc. In this paper, a class of Chemostat dynamical model with inhibitory exponential substrate uptake and a time delay is proposed. Then, by stability theory of delay differential equations and Liapunov-LaSalle invariant principle, a detailed theoretical analysis for boundedness of the solutions and stability of the equilibria of the model are carried out.

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Key words and phrases. Chemostat model, time delay, stability.

A diffusive competition model with a protection zone

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Abstract: To save or protect certain species, among many other means, the human being uses a variety of protection zones. In this talk, we report our recent research on the diffusive competition model in the hypothetical situation that the weaker of the two species is protected from its competitor in a subregion of the habitat (called a protection zone), where the protected species can leave and enter freely but its competitor is blocked out.

Bifurcation Analysis of Predator-Prey Systems with Constant Rate Harvesting Using Non-Standard Discretization

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Abstract. We formulate and apply non-standard discretization methods that enable us to study the saddle, elliptic and parabolic cases of the predator-prey system with constant rate harvesting as difference dynamical systems. Our models have the same qualitative features as their corresponding continuous models. By choosing appropriate bifurcation parameters, we combine analytical and numerical investigations to produce interesting global bifurcation diagrams, including saddle-node, Hopf and Bogdanov-Takens bifurcations.

***Keywords*:** Dynamical systems; difference equations; nonstandard schemes.
AMS Subject Classification: Primary 34C23, 39A05; secondary 37G15.

[1] **Acknowledgement:** The author wish to thank the referees of this journal for their worthwhile comments to greatly improve the paper.

IMPACT OF INVASIVE ALIEN SPECIES AND ITS CONTROL

MENG FAN

Invasive species impact biodiversity, habitat quality, and ecosystem functioning. The threat to biodiversity due to invasive alien species is considered second only to that of habitat loss.

One of the most important topic on biological invasion is to understand the role played by invasive alien species and address the impact of the invasive alien species. Then we can design scientific management strategies.

In this talk, we will review our recent findings on this topic. The main context is based on our following papers:

- Meng Fan, Yang Kuang, Zhilan Feng. Cats protecting birds revisited, Bulletin of Mathematical Biology, 2005, 67:1081-1106.
- Jimin Zhang, Meng Fan, Yang Kuang. Rabbits killing birds revisited, Mathematical Biosciences, 2006, 203(1):100-123.

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1991 *Mathematics Subject Classification.* The AMS Subject Classification.
Key words and phrases. Invasive alien species, impact, control.

A DISCRETE S-I-R MODEL WITH GENERAL FUNCTION OF REMAINING SUSCEPTIBLE PROBABILITY

ZHENG FANG AND LIU XIAN-NING

This paper studies a discrete S-I-R disease transmission model, in which the probability of remaining susceptible is a general function of the infected population. The basic reproduction number is established. Existence and stability of equilibria are studied with conditions only related to this number. Conditions for permanence and global stability of the system are also obtained. Mathematical results of the model suggested that overcrowded population may be the reason for disease spread and improving the medical technology is effective for disease control.

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1991 *Mathematics Subject Classification.* The AMS Subject Classification.
Key words and phrases. Discrete; S-I-R model; Uniform persistence; Global stability.

A DISCRIMINATION MEASURE FOR PHYLOGENETIC TREE CONSTRUCTION

JIE FENG AND TIAN-MING WANG

Traditional approaches for phylogenetic analysis require a multiple alignment and therefore are not directly applicable to complete genomes, besides, all of these methods assume some sort of an evolutionary model which may not always be correct. We present a new sequence distance based on the relative information between the sequences using discrimination measure. By making use of the obtained distance matrix, we can construct phylogenetic tree.

Our goal in this paper is not to confirm or disprove previous phylogenetic studies but to bring a new methodology and a new tool to the comparative genomics research community. we provide a new scale for the discrimination between two sequences. The proposed discrimination measure reflects the degree that one sequence distinguishes from another sequence. By making use of the obtained distance matrix, we construct a phylogenic tree for eutherians using whole mtDNA. The examination of topology belong to twenty species illustrates the utility of our approach.

Different from most existing phylogeny construction methods, the proposed method does not require multiple alignments and is fully automatic. Therefore, we are able to perform whole genome-based phylogenetic analysis. Furthermore, it handles both of the cases unequal sequence length and the relatively different positioning of similar regions between sequences naturally. It works when there are no evolutionary models. Another possible use of our method is to find some genes that cause some diseases from comparison of abnormal gene sequence and normal gene sequence.

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Key words and phrases. Discrimination Measure, Phylogenetic Tree.

Influence of anti-viral drug treatments on evolution of HIV-1 pathogen

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Abstract: An age-structured model is used to study the possible impact of drug treatment of infections with the human immunodeficiency virus type 1 (HIV-1) on evolution of the pathogen. Different types of drugs (e.g., reverse transcriptase inhibitors, protease inhibitors and entry inhibitors) help to reduce the HIV replication at different stages of the cell infection, and the use of an age structure allows us to more realistically model the effect of these drugs. Inappropriate drug therapy offen leads to the development of drug-resistant mutants of the virus. Previous studies have shown that natural selection within a host favors viruses that maximize their fitness. By demonstrating how drug therapy may influence the within host viral fitness we show that while a higher treatment efficacy reduces the fitness of the drug-sensitive virus, it may provide a stronger selection force for drug-resistant viruses which allows for a wider range of resistant strains to invade.

Reproductive strategy of perennial plant in different resource gradients[1]

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Abstract: A lot of higher plant species can produce both seeds and vegetative propagules. The trade-off between these two reproductive modes is flexible in resource variational environment. So the balance between seed and vegetative reproduction is a key factor for reproductive success. A density-dependent transition matrix model was established to study which kind of reproductive strategy plants would be selected in different resource gradients. The results show that plants tend to allocate more resources to seed reproduction when available resources are short in the habitat. Plants will allocate more and more resources to vegetative propagules with the increasing of resources, but plants will produce more seeds instead of vegetative propagules for the purpose of escaping current habitat if resources keep increasing to harmful level. We also discussed how attributes of plant affect the optimal reproductive strategy and compared our result with some former resource allocation models.

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THE MODELING AND ANALYZING OF A PREDATOR-PREY SYSTEM WITH EPIDEMIC IN THE PREY

YONGCHANG FU AND ZHIXING HU

In this paper, a predator-prey XSI model in which the prey is epidemic, is formulated and analyzed. The basic assumptions referred in the model are listed below: First, in order to investigate how the predation process influences the epidemics, we consider the simple case when the predator mainly eats the infected prey, that is the amount of the predator mainly holds by preying the infected prey and is restricted by group density; second, the increasing of the susceptible prey is restricted by the density of both the susceptible prey themselves and the infective prey, with the same restricting coefficients of the two factors; finally, the increasing of the infective prey will also be limited by the reason of competing for the resource. On the basic assumptions above and the general thought of studying the epidemic dynamics models, the model referred in the paper is formulated as follows:

$$\begin{cases} \dfrac{dX}{dt} = -dX + ekIX - aX^2 \\ \dfrac{dS}{dt} = r(S+I) \quad 1 - \dfrac{S+I}{K} \Big) - \beta SI + \delta I \\ \dfrac{dI}{dt} = \beta SI - cI - kIX - bI^2 - \delta I \end{cases}$$

Based on the mathematic model above, several theorems are obtained as follows:

Theorem 1 The system is ultimately bounded.

Theorem 2 If $\beta K - c - \delta < 0$, then the disease-free equilibrium $E_1(0, K, 0)$ is globally asymptotically stable.

Theorem 3 If $\beta K - c - \delta > 0$, then there exists the equilibrium $E_2(0, S_2, I_2)$, and when $d - ekK > 0$, it is globally asymptotically stable.

Theorem 4 If $c+\delta-\dfrac{kd}{a} > 0$ and $\beta K > c+\delta-\dfrac{kd}{a}$, there exists an positive solution I^* for the variable I of the system, and for the above $I^* > 0$, if $d - ekI^* < 0$, there exists an unique positive equilibrium $E^*(X^*, S^*, I^*)$, and it is locally asymptotically stable in the same condition

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Key words and phrases. Equilibrium; locally asymptotical stability; global asymptotical stability.

BIFURCATION ANALYSIS FOR A DIFFUSIVE PREDATOR-PREY MODEL WITH TIME DELAY

QINTAO GAN AND RUI XU

In this paper, a predator-prey model with prey dispersal and time delay is investigated. We first consider the linear stability and the existence of a Hopf bifurcation. Then, using the normal form theory and center manifold reduction, the explicit formulae are derived to determine the stability, direction and other properties of bifurcating periodic solutions. Finally, numerical simulations are given to illustrate the theoretical predictions.

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Key words and phrases. Hopf bifurcation, periodic solutions, stability.

STABILITY ANALYSIS OF THE NONLINEAR IMPULSIVE SYSTEM IN MICROBIAL FED-BATCH FERMENTATION

CAIXIA GAO AND ENMIN FENG

In this study, the nonlinear impulsive dynamical system of fed-batch fermentation is investigated in the process of bio-dissimilation of glycerol to 1,3-propanediol. Several stability criteria are established by employing the method of Lyapunov functions. Numerical experiments are carried out according to the actual microbial fermentation.

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1991 *Mathematics Subject Classification.* 34K45, 49N25, 49N90.
Key words and phrases. Stability, Lyapunov function; nonlinear impulsive system.

ANALYSIS OF AN SEIRS EPIDEMIC MODEL WITH TIME DELAYS AND PULSE VACCINATION

SHUJING GAO AND ZHIDONG TENG

Pulse vaccination is an important strategy for the elimination of infectious diseases. An SEIRS epidemic model with time delays and pulse vaccination is formulated in this paper. Using the discrete dynamical system determined by the stroboscopic map, we obtain the exact periodic infection-free solution of the impulsive epidemic system and prove that the infection-free periodic solution is globally attractive if $R^* < 1$. Moreover, we show that the disease is uniformly persistent if $R_* > 1$. The permanence of the model is investigated analytically. Our results indicate that a long period of pulsing or a short latent period of the disease is sufficient condition for the permanence of the model.

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Key words and phrases. Time delay, Pulse vaccination, SEIRS epidemic model, Global attractivity, Permanence.

MODELS FOR AN OUTBREAK OF AVIAN INFLUENZA IN THE BRITISH POULTRY FLOCK

TINI GARSKE

The identification of H5N1 in domestic poultry in Europe last year has increased the risk of infection reaching most industrialized poultry populations. Here, using detailed data on the poultry population in Great Britain, we develop a network model for the spread of avian influenza between poultry premises. We show that interventions based on rapid isolation of infected premises and movement restrictions can be expected to control the majority of outbreaks. A predictor of the need to intensify control efforts in Great Britain is whether an outbreak exceeds 20 infected premises. In such a scenario neither localised reactive vaccination nor localised culling are likely to have a substantial impact. The most effective of these contingent interventions are large-radius (10km) localised culling and national vaccination. However, the modest impact of these approaches must be balanced against their substantial effort and cost.

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1991 *Mathematics Subject Classification.* 92D30.

Key words and phrases. avian influenza, poultry, control.

PERIODIC SOLUTIONS OF PIECEWISE AFFINE GENE NETWORK MODELS

JEAN-LUC GOUZÉ AND ETIENNE FARCOT

This work deals with the search of periodic solutions of a class of piecewise-affine systems of differential equations. Such models have been studied both theoretically, and as models of concrete biological systems. The analysis of periodic solutions is rather complete if the decay rates of all variables are supposed equal. However, it is biologically much more plausible to use distinct decay rates, since different elements in these systems have distinct characteristic time scales. Using fixed point results for monotone and concave operators, we show that it is possible to obtain some new results of existence and uniqueness of limit cycles with arbitrary decay rates. These results are valid provided some hypothesis are made on the interaction structure of these systems. In particular, they hold for negative feedback loop systems, allowing us to extend a previous results of E.H. Snoussi.

Reference: Farcot, Etienne and Gouzé, Jean-Luc, Periodic solutions of piecewise affine gene network models: the case of a negative feedback loop, INRIA Report 6018, 2006, http://hal.inria.fr/inria-00112195

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Key words and phrases. Genetic networks, piecewise-linear systems, periodic solutions.

THE EFFECTS OF CROP HARVEST ON BIOLOGICAL PEST CONTROL

S. NUNDLOLL[†], L. MAILLERET[‡] AND F. GROGNARD[†]

In this contribution, the effects of periodic partial harvesting of a continuously grown crop (*e.g.* ornamental) on impulsive biological control are analyzed. Since this partial harvesting can also entail the partial removal of both pests and biological control agents, its influence on the biological control efficiency cannot be *a priori* neglected. The modelling approach proposed *e.g.* by [1,3] is followed so that our model consists of a general predator-prey model in ODE as described in [2], augmented by a discrete component to depict the periodic harvesting (with period T_h) and releases of biological control agents (with period T_r). In this study, these periods are taken as multiples of each other. Thus, we get:

$$\begin{cases} \dot{x} = f(x) - g(x)y \\ \dot{y} = h(x)y - dy \\ x(nT_h^+) = (1-\alpha_x)x(nT_h) & \forall n \in \mathbb{N} \\ y(nT_h^+) = (1-\alpha_y)y(nT_h) + \delta\left(nT_h \bmod T_r\right)Y & \forall n \in \mathbb{N} \\ y(mT_r^+) = (1-\delta\left(mT_r \bmod T_h\right)\alpha_y)y(mT_r) + Y & \forall m \in \mathbb{N} \end{cases}$$

where x and y are the prey (pests) and predator (biocontrol agents) populations respectively. $\delta(.)$ is such that $\delta(0) = 1$, which occurs only at instants where harvesting and release coincide, and is equal to zero otherwise. α_i represents the proportion of organisms i removed through harvest and Y the amount of predators released at each 'injection'.

A stability condition for pest eradication is expressed as the minimal value of the budget to spend on predators releases per unit time. The result obtained by [2], that does not consider crop harvest, provides a benchmark against which the effects of partial harvest are compared. For a given T_h, it is shown that when $T_r \geq T_h$, the budget is independent of T_r at a value μ. However, when releases take place more often than harvests, the minimum budget always exceeds this μ. A discussion on the implications on the control strategy to implement concludes this work.

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Key words and phrases. Impulsive biological control, periodic partial harvest.

PERIODIC SOLUTION AND CHAOTIC STRANGE ATTRACTOR FOR HOPFIELD-TYPE NEURAL NETWORKS WITH IMPULSES

ZHANJI GUI AND XIAO-SONG YANG

By using the continuation theorem of coincidence degree theory and constructing suitable Lyapunov functions, we study the existence, uniqueness and global exponential stability of periodic solution for Hopfield-type neural networks with impulses. Further the numerical simulation shows that our system can occur many forms of complexities including periodic oscillation and chaotic strange attractor.

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Key words and phrases. Hopfield neural network; impulse; chaotic strange attractor; Periodic solution; Numerical simulation.

THE BIRTH AND DEATH EQUATION OF VIRUS SPREADING

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Abstract: This article from the complex network new angle, utilizes in the stochastic approaches of the non-equilibrium statistical theory, has studied virus dissemination mechanism. In the SIS model foundation, we derived the Birth and Death Equation of viral dissemination, namely the SIS-BD model, and used the generating function method, obtained the infection density function along with the time distributed rule of viral dissemination which approach more in the real process. From a side, it is proved that the virus will be able coexistence with the environment in very long period of time, and provided a new angle of view and some deeper understanding for the viral dissemination theory investigation, and benefited to study and utilize the new immunity strategy to maintain the environmental safety.

Keywords: *virus spreading, complex network, stochastic approaches, SIS-BD model, birth-death equation, generating function*

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DYNAMIC BEHAVIORS OF A KIND OF PREDATOR-PREY SYSTEM WITH IVLEV'S AND BEDDINGTON-DEANGELIS' FUNCTIONAL RESPONSE AND IMPULSIVE EFFECT

HONGJIAN GUO, XINYU SONG, AND LANSUN CHEN

A kind of one-prey two-predator system with Ivlev's and Beddington-DeAngelis' functional response and impulsive release at fixed moment is presented and investigated in this paper. We show the system has a prey-eradication periodic solution. By using the Floquet theory and small amplitude perturbation skills, it is proved that the prey-eradication periodic solution of the system is locally asymptotically stable when the period of impulsive effect is less than some critical value. Furthermore, permanence of the system is investigated and the condition of permanence is obtained. Finally, numerical simulations show that the system has complex properties which include periodic solution, period-doubling bifurcation, chaos, chaotic windows, half-period bifurcation. A brief discussion of our results and their relation between continuous system and the impulsive system of this paper are given. The results obtained in this paper are confirmed by numerical simulation.

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Key words and phrases. Predator-prey system; Impulsive effect; Permanence; Extinction, Bifurcation.

GLOBALLY EXPONENTIAL STABILITY OF NEURAL NETWORKS SYSTEMS WITH TIME DELAYS

JIN-FANG HAN, JI-QING QIU, AND HUI-ZHI YANG

The authors analyze the existence of the equilibrium point and global exponential stability for Hopfield-type neural networks with time-varying delays by means of the topological degree theory and generalized Halanay inequality. Since the diffusion phenomena and time delay could not be ignored in neural networks and electric circuits, the model presented here is close to the actual systems, and the sufficient conditions on global exponential stability established in this paper, which are easily verifiable, have a wider adaptive range.

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Key words and phrases. Neural Networks; Globally Exponential Stability; Matrix Measure; Time Delays; Topological Degree.

Oscillation for a Class of Second Order Emden-Fowler Delay Dynamic Equations on Time Scales *

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Abstract: By means of Riccati transformation technique, we establish some new oscillation criteria for the second order Emden-Fowler delay dynamic equations

$$(rx^{\Delta})^{\Delta}(t) + p(t)x^{\gamma}(\tau(t)) = 0$$

on a time scale $\mathbb{T}$; here γ is a quotient of odd positive integers with $r(t)$ and $p(t)$ real-valued positive rd-continuous functions defined on $\mathbb{T}$. To the best of our knowledge nothing is known regarding the qualitative behavior of these equations on time scales. Our results in this paper not only extend the results given in Agarwal *et al* [2] but also unify the oscillation of the second order Emden-Fowler delay differential equation and the second order Emden-Fowler delay difference equation.

Keywords: Oscillation; Second order; Delay dynamic equations; Time scale.

Mathematics Subject Classification 2000: 34A99

CONTROL PROBLEMS OF AN AGE-DEPENDENT PREDATOR-PREY SYSTEM

ZE-RONG HE AND WEN-XIANG ZHOU

This paper is concerned with optimal harvesting problems for a system consisting of two populations with age-structure and interaction of predator-prey. Existence and uniqueness of non-negative solutions to the system and the continuous dependence of solution on control variable are investigated. Existence of optimal policy is discussed, optimality conditions are derived by means of normal cone and adjoint system technique.

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Key words and phrases. Predator-prey, species model, optimal control, age-structure, maximum principle.

AN AGE-DEPENDENT INFLUENZA MODEL FOR EVALUATING VACCINE STRATEGIES

YING-HEN HSIEH AND JOHN GLASSER

Even if universal vaccination were desirable or available during a flu pandemic, those most vulnerable (i.e., the youngest and oldest), and those who would maintain social order (e.g., firefighters, policemen), care for ill people, etc., should have priority. Using an age-dependent SEIR model, we compared targeting children and adults in populations mixing realistically (i.e., non-randomly). We simulated annual influenza outbreaks in age-structured models with and without childhood or adult vaccination, and with vaccination for schoolchildren. The results are useful for determining the appropriate vaccine strategies when facing future pandemic.

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Key words and phrases. Influenza pandemic; vaccination; age-dependence; SEIR model; targeting strategy.

Mathematical Modeling of the Effect of Disease in Ecological System

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Abstract: One of the biggest challenges facing ecologists today is to understand how, and to what extent, interspecific interactions influence community structure, species coexistence and biodiversity. Coupled with this is an increasing awareness of the potential importance of parasites and pathogens in determining the outcomes of trophic interactions. In this talk we shall present several resources-based competition models mediated with parasites. We analyze the models and show how parasites affect interactions between competitors.

THE ANALYSIS OF TWO EPIDEMIC MODELS WITH CONSTANT IMMIGRATION AND QUARANTINE

ZHIXING HU AND YANG YU

In this paper, assume the total population divided into four classes: the susceptible class S, the normal infectious class I in which the individuals are not quarantined, the quarantined infectious class Q, in which the individuals have been removed and isolated either voluntarily or coercively from the infectious class, and the removed class R. Combining the models with classifying immigration and the models with quarantine, we construct a $SIQS$ model and a $SIQR$ model which incorporate constant immigration and quarantine for the special case of the simple mass action incidence rate. The decline of the disease-related death rate and the increase of the individuals' recovery rate after the individuals being quarantined are considered in the paper. Then, the unique endemic equilibriums of the two models are attained, the local and global stability of the endemic equilibriums are also proved. Consider the following $SIQS$ model, where the infection does not confer immunity. In the model, some of the susceptible individuals become infected and then some infected individuals remain in the I class for their entire infectious period before they return to the susceptible class, while other infected individuals are transferred into a quarantined class Q. The individuals in infectious class including the normal infectious class I and the class Q of quarantined individuals remain there until they are no longer infectious, at which time they return to the susceptible individuals. $SIQS$ model is following equation:

$$\begin{cases} S' = (1-p)A + \gamma_1 I + \gamma_2 Q - dS - \beta SI, \\ I' = \beta SI + pA - (\gamma_1 + d + \alpha_1 + \delta)I, \\ Q' = \delta I - (d + \alpha_2 + \gamma_2)Q. \end{cases} \tag{1}$$

We get following conclusion:

Lemma 1 When $0 < p \leq 1$, the system (1) have unique positive equilibrium $P^*(I^*, Q^*, N^*)$ which is locally asymptotically stable. Theorem1 When $0 < p \leq 1$, the endemic equilibrium P^* of the system (1) is always global asymptotically stable.

On the basic of $SIQS$ model, we assume that the infected individuals transfer to removed class, in which the individuals have immunity from the epidemic. In this model, some of the susceptible individuals become infected and then some infected individuals remain in the I class for their entire infectious period before they gain the immunity and enter the removed class, while other infected individuals are transferred into a quarantined class Q. The individuals in infectious class including the normal infectious class I and the class Q of quarantined individuals remain there until they are no longer infectious, at which time they return to the susceptible individuals. $SIQR$ model is following equation:

$$\begin{cases} S' = (1-p)A - dS - \beta SI, \\ I' = pA + \beta SI - (\gamma_1 + d + \alpha_1 + \delta)I, \\ Q' = \delta I - (d + \alpha_2 + \gamma_2)Q, \\ R' = \gamma_1 I + \gamma_2 Q - dR. \end{cases} \tag{2}$$

We get following conclusion:

Theorem 2. when $0 < p \leq 1$, the endemic equilibrium P^* of the system (2) is global asymptotically stable.

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Key words and phrases. Epidemiological models; Quarantine; Immigration; Endemic equilibrium; Global Stability.

GLOBAL PROPERTY OF AN INVASIVE DISEASE WITH N-STRAINS

SHINGO IWAMI AND TADAYUKI HARA

The competitive exclusion principle is one of the most interesting and important phenomena in the feild of theoritical epidemiology and biology. We provide a strict and an elegant mathematical analysis related this phenomenon for an n-strain disease model by the average Lyapunov function theorem and some dynamical system theory. Furthermore, we can show that an equilibrium in which only the strain with the maximum basic reproductive number exists is globally asymptotically stable. This result was anticipated by Bemmermen and Thieme in their 1989 paper where they showed that the equilibrium is locally stable — the global result has not been established previously.

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Key words and phrases. SIRS model; N-strain; Competitive exclusion; Globally asymptotically stable.

The leading eight: social norms that can maintain cooperation by indirect reciprocity

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Theory of indirect reciprocation explains the evolution of cooperation among unrelated individuals, engaging in one-shot interaction. Using reputation, a player acquires information on who are worth cooperating and who are not.

[1] We formalized the reputation dynamics, a rule to assign a binary reputation (good or bad) to each player when his action, his current reputation, and the opponent's reputation are given. We then examined all the possible reputation dynamics, and found that there exist only eight reputation dynamics named " leading eight" that can maintain the ESS with a high level of cooperation, even if errors are included in executing intended cooperation and in reporting the observation to the public.

[2] We also study the nature of these successful social norms. We characterize the role of each pivot of the reputation dynamics common to all of the leading eight. We conclude that keys to the success in *indirect* reciprocity are to be nice (maintenance of cooperation among themselves), retaliatory (detection of defectors, punishment, and justification of punishment), apologetic, and forgiving. Second we prove the two basic properties of the leading eight, which give quantitative evaluation of the ESS condition and the level of cooperation maintained at the ESS.

[3] Third, we explore the global dynamical behavior of multiple behavioral strategies by replicator dynamics. When private errors exist to a small extent, the stable coexistence of unconditional and conditional cooperators under suitable norms.

[4] Finally we extend the results to the situations in which players can choose costly punishment, as well as cooperation and defection. Results remain unchanged qualitatively.

ENDOPHYTE MEDIATED PLANT SPECIES COEXISTENCE -WITH OR WITHOUT PREDATOR-

SHIGEHIDE IWATA AND YASUHIRO TAKEUCHI

Almost plant species live on the mutualistic symbiosis with mycorrhizae or microorganisms. One of microorganisms is endophyte fungi which coexist within the plant species. The fungi give The plants use the secondary metabolite of the fungi to fight against for desiccating or insects. Furthermore, it is reported that plants infected by endophyte change the ecosystem construction (Omachi et al. 2001). Hence, it is important to understand the dynamics for the system with plants, endophyte and predator and we study the dynamics by using the difference equations based on a lottery model (Chesson and Warner 1981).

We show that the plants become able to coexist with predators even if plant with endophytecan not coexist without herbivores.

Biogeography

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Key words and phrases. Key Words and Phrases:plant species, lottery model, endophyte, coexistence,

Competitive Exclusion and Coexistence in a Nonlinear Refuge-Mediated Selection Model

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Abstract. A selection model with n traits is considered. It is assumed that the mortality function is density dependent and that individuals with "weak" traits are able to disperse to a safe refuge patch and avoid competition with individuals carrying the strongest trait. It is shown that if any subpopulation with a "weak" trait does not have a safe refuge then it will become extinct. Therefore, for survival of n traits $n-1$ safe refuge patches are needed. When $n-1$ refuge patches are available global stability results of the interior equilibrium is proved provided that the fittest trait is sufficiently better than the other traits. Finally, two special cases with linear and Beverton-Holt density dependent mortality functions are studied in detail.

Dynamic complexities in the chemostat with impulsive perturbations and Beddington-DeAngelis functional response

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Abstract: In this paper, we introduce and study a model of a predator-prey system with Beddington-DeAngelies type functional response under periodic pulsed chemostat conditions, which contains with predator, prey, and periodically pulsed substrate.We investigate the subsystem with substrate and prey and study the stability of the periodic solutions, which are the boundary periodic solutions of the system. The stability analysis of the boundary periodic solution yields an invasion threshold. By use of standard techniques of bifurcation theory, we prove that above this threshold there are periodic oscillations in substrate, prey and predator.Simple cycles may give way to chaos in a cascade of period-doubling bifurcations. Furthermore, by comparing bifurcation diagrams with different bifurcation parameters, we can see that the impulsive system shows two kinds of bifurcations, whose are period-doubling and period-halving.

Keywords: Global Stability, Periodic Solution, Chaos, Period-Doubling Bifurcation, Period-Halving Bifurcation.

Mathematical Model of Velocity Variations on 100m Race

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Abstract

To find out the optimal velocity in a race, T. B. Keller created a velocity variation model

$$\mathrm{d}V / \mathrm{d}t + V / s = F$$

$$V(0) = 0$$

In this model the F is a constant. The solution can be expressed as

$$V(t) = F\, s\, (1 - \mathrm{e}^{-t/s})$$

It is increased function, it only can be used to describe the getting off.

In fact, F should be an attenuating function based on physiology. In this paper, a new model below is obtained

$$\mathrm{d}V / \mathrm{d}t + V / s = F\, \mathrm{e}^{-t/\mathrm{k}}$$

$$V(0) = 0$$

The validation is down based on 100m race data of top 6 athletes in xx Olympic Games. The result shows us that the model can be used to find out optimal velocity distribution of athletes.

COMPLETE CONVERGENCE FOR WEIGHTED SUMS OF $\widetilde{\rho}$-MIXING RANDOM VARIABLE SEQUENCES

WU QUNYING AND JIANG YUANYING

In this paper, we study the weak convergence and complete convergence for $\widetilde{\rho}$-mixing random variable sequences. As a result, we extend the classical weak law of large numbers, and Baum and Katz complete convergence theorem etc. for independent random variable sequences to $\widetilde{\rho}$-mixing random variable sequences without necessarily adding any extra conditions..

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Key words and phrases. $\widetilde{\rho}$-mixing random variable sequence; weak law of large numbers; complete convergence.

Global attractivity of a stage-structure variable coefficients predator-prey system with time delay and impulsive perturbations on predators *

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Abstract. In this work, we consider a delayed stage-structured variable coefficients predator-prey system with impulsive perturbations on predators. By using the discrete dynamical system determined by stroboscopic map and the standard comparison theorem, sufficient conditions which guarantee the global attractivity of pest-extinction periodic solution of the system are obtained. We also prove that all solutions of the system are uniformly ultimately bounded. Our results provide reliable tactic basis for the practical pest management.

Keywords: Stage-structured; Time delay; Impulsive; Global attractivity; Pest-extinction

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STUDY ON DESIGN OPTIMIZATION OF WHEAT GROWTH UNDER COMPOUND SYSTEM IN NORTH CHINA PLAIN

JING YUANSHU, WU YUNY, AND STEVEN M. NEWMAN

As a useful ecological system to promote the productivity of land, *Paulownia (Paulownia elongate)*-crop intercropping has been adopted extensively as a new farming system in Huang-Huai-Hai of North China Plain. To-date, about 2 million ha of farmland have been used for intercropping of *Paulownia* with wheat , corn, cotton, tea, medicinal plants and other cash crops. *Paulownia*-crop intercropping provides favorable growth conditions for wheat. Wheat's light saturation point was low about 50% of the total solar radiation, so that wheat is a very promising crop for intercropping among local crops. Yield of wheat in the *Paulownia*-crop intercropping system varies with the seedtime, seeding quantity, the distance from *Paulownia* row and so on. Further improvement on design optimization of wheat growth on *Paulownia*-crop intercropping is needed to promote greater wheat yield increase.

The study was conducted at Chengwu Paulownia Research Base in Shandong Province. The mean annual rainfall is 661.3 mm and annual air temperature is 14.0 C°. The soil was sandy and alkaline. Measurements were carried out on 24.9 ha of *Paulownia*-wheat intercropping system with a north-south orientation. A Randomized Complete Block Design (RCBD) with three replicates of 11-year *Paulownia* in plantations of spacing with 32 m. Both crown width of west-east and south-north direction for *Paulownia* was 8.5 m with canopy closure 13%. The seeding date began in October of first year and harvest date ended in June of next year. Twenty plots of different seedtime, seeding quantity, the distance from *Paulownia* row were designed for optimization modeling of wheat growth. Irrigation for wheat re-green over winter was done in middle March. The seedling, shooting, effective tillering, grain weight, mass weight, and yield of wheat were investigated during growth and maturity.

In the context of experiment observations and the quadratic regression revolution design, a group of models are established for three controllable seeding factors and dynamic indices of wheat mass development between forest belts, with the yield effect related to one and all of the factors investigated. It was sorted out to provide assistance for normalized seeding and prediction and control in advance of the wheat for purposes of high yield more than 5100 kg ha^{-1} of an optimal scheme, being seedtime between October 2nd and 11th, seeding quantity between 115.3 kg ha^{-1} and 138.2 kg ha^{-1}, and the distance from *Paulownia* row between 13.6 m and 19.9 m under local agricultural productive conditions.

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Key words and phrases. Compound *Paulownia* system, revolution design, optimization modeling, mass development, high yield.

THE EXISTENCE OF POSITIVE PERIODIC SOLUTIONS OF AN ECO-EPIDEMIC MODEL WITH IMPULSIVE BIRTH

AIHUA KANG AND YAKUI XUE

The eco-epidemic models have been extensively studied by several researchers. Previous works on the models are considering the continuous birth, whereas many animals give birth only during a single period of the year.In this paper, we considered an eco-epidemic model with the disease in the predator and impulsive birth. As following:

$$\left\{\begin{array}{l} \left.\begin{array}{l} \dot{x}(t) = x(-d_1(t) - a(t)x - b_1(t)y_1 - b_2(t)y_2) \\ \dot{y_1}(t) = y_1(-d_2(t) + c(t)x - k_1(t)(y_1 + y_2) - \beta(t)y_2) \\ \dot{y_2}(t) = y_2(\beta(t)y_1 - k_2(t)(y_1 + y_2)) \end{array}\right\} \quad t \neq t_k \quad k \in Z, \\ \left.\begin{array}{l} x(t_k^+) = (1 + b_{1k})x(t_k^-) \\ y_1(t_k^+) = (1 + b_{2k})y_1(t_k^-) \\ y_2(t_k^+) = y_2(t_k^-) \end{array}\right\} \qquad t = t_k \quad k \in Z. \end{array}\right.$$

where the number of the prey population, sound predator population, and infected predator population are denoted by $x(t)$, $y_1(t)$ and $y_2(t)$ respectively; $d_1(t)$ and $d_2(t)$ are natural death rates of the prey and predator,respectively; b_{1k} , b_{2k} represent growth of birth pulse for the prey $x(t)$ and the sound predator $y_1(t)$ at t_k , respectively. All coefficients are continuous positive periodic functions with a constant T.

By using the coincidence degree theorem,we obtained a set of easily verifiable sufficient conditions for the existence of at least one strictly positive periodic solutions.

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Key words and phrases. impulsive birth, periodic solutions, coincidence degree theory, existence, eco-epidemic model.

Existence and global asymptotic stability of almost periodic solutions for static neural networks with time-varying delays

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Abstract: In this paper, using the theory of fixed point and Liapunov functional methods, we study the existence and global asymptotic stability of almost periodic solutions for static neural networks with variable coefficients and time-varying delays. The results are new and complement previously known results.

Main results: we consider the following static neural networks with variable coefficients and time varying delays

$$\frac{dx_i(t)}{dt} = -c_i(t)x_i(t) + f_i(\sum_{j=1}^{n} a_{ij}(t)x_j(t-\tau_{ij}(t)) + I_i(t)) + g_i(\sum_{j=1}^{n} b_{ij}(t)x_j(t) + I_i(t)), \quad i = 1,2,\mathrm{K}\ ,n \tag{1.1}$$

Throughout this paper, we assume that the following conditions hold:

(H1) $c_i(t), a_{ij}(t), b_{ij}(t), I_i(t), \tau_{ij}(t), i = 1,2,\mathrm{K}\ ,n$, are continuous almost periodic functions on R, and $\tau = \max_{t\in[0,\omega]}\{\tau_{ij}(t) \geq 0,\ \ i,j = 1,2,\mathrm{K}\ ,n\}$ is a constant.

(H2) for all $u_i, v_i \in R$ For each $i = 1,2,\mathrm{K}\ ,n$, $f_i, g_i : R \to R$ has Lipschitz constant σ_i, δ_i, respectively, i.e.,

$$|f_i(u_i) - f_i(v_i)| \leq \sigma_i|u_i - v_i|,\ \ |g_i(u_i) - g_i(v_i)| \leq \delta_i|u_i - v_i|, \text{ for all } u_i, v_i \in R.$$

(H3) For each $i,j = 1,2,\mathrm{K}\ ,n$, choose constants $\underline{c}_i, \overline{a}_{ij}, \overline{b}_{ij}, \overline{I}_i$, such that

$$\underline{c}_i = \inf_{t\in R}|c_i(t)| > 0, \overline{a}_{ij} = \sup_{t\in[0,\omega]}|a_{ij}(t)| > 0, \overline{b}_{ij} = \sup_{t\in[0,\omega]}|b_{ij}(t)| > 0, \overline{I}_i = \sup_{t\in[0,\omega]}|I_i(t)| > 0$$

(H4) $\eta = \max\{\underline{c}_i^{-1}\sum_{j=1}^{n}(\sigma_i\overline{a}_{ij} + \delta_i\overline{b}_{ij})\} < 1$, $D = \underline{C} - (\sigma\overline{A} + \delta\overline{B})$ is an $M-$matrix, where $\overline{B} = (\overline{b}_{ij})_{n\times n}$,

$$\underline{C} = = diag(\underline{c}_1, \underline{c}_{2,\Lambda}, \underline{c}_n),\ \ \overline{A} = (\overline{a}_{ij})_{n\times n},\ \ \sigma = = diag(\sigma_1, \sigma_{2,\Lambda}, \sigma_n), \delta = = diag(\delta_1, \delta_{2,\Lambda}, \delta_n)$$

Theorem 3.1 *Suppose that (H1)-(H4) hold. Then the system (1.1) has exactly one almost periodic solution* $x^*(t)$. *Moreover,* $x^*(t)$ *is globally asymptotic stable.*

EVALUATION OF RIVER WATER QUALITY OF PHYSIC-CHEMICAL AND BIOLOGICAL FACTORS USING FUZZY MATHEMATICS

QIANG KE AND QI WANG

Abstract: Fuzzy mathematics theory was applied for decision-making in the assessment of physic-chemical and biological factors quality of surface water. The subordination function, distribution coefficient of various factors weight concept, and fuzzy compound operation has been introduced. The method overcomes the disadvantages of great subjectivity of some traditional methods and improve the evaluation effect. As one of the main rivers, the water quality of Aojiang river greatly influenced the ecological environment of Pingyang county ,it is of great significance to evaluate its water quality objectively.The paper applied the method to evaluation of water quality for Aojiang river on the basis of the monitored data. The method, which integrates lots of water quality indexes and thinks about single gene contribute and correlation between each other,is scientific.

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Key words and phrases. Fuzzy mathematics; River water quality; AoJiang.

QUALITATIVE PERMANENCE OF LOTKA-VOLTERRA EQUATIONS

JOSEF HOFBAUER, RYUSUKE KON, AND YASUHISA SAITO

In this talk, we consider permanence of Lotka-Volterra equations:

$$\dot{x}_i = x_i(r_i + \sum_{j=1}^{n} a_{ij}x_j), \quad i = 1, 2, \ldots, n.$$

We are concerned with the sign structure of the interaction matrices $A = (a_{ij})$ that lead to permanent Lotka-Volterra equations whenever it has a positive equilibrium point. An interaction matrix with such a property is said to be qualitatively permanent. More precisely, a square matrix $A = (a_{ij})$ is said to be qualitatively permanent if

$$\dot{x}_i = x_i \sum_{j=1}^{n} \widetilde{a}_{ij}(x_j - x_j^*), \quad i = 1, 2, \ldots, n$$

is permanent for all $\widetilde{A} = (\widetilde{a}_{ij}) \in Q_A$ and $\mathbf{x}^* > \mathbf{0}$. Here Q_A is the set of matrices with the same sign pattern as A. Our results provide both necessary and sufficient conditions for qualitative permanence. If $n \leq 3$, then our necessary condition becomes sufficient. The sharpness of our sufficient condition is also discussed.

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Key words and phrases. average Liapunov function, P-matrix, VL-stability.

Resource quality dynamics and its implications

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Mathematical biologists have built on variants of the Lotka–Volterra equations and in almost all cases have adopted the pure physical science's single-currency (energy) approach to understanding population dynamics. However, biomass production requires more than just energy. It is crucially dependent on the chemical compositions of both the consumer species and food resources. In this talk, we explore how depicting organisms as built of more than one thing (for example, C and an important nutrient, such as P) in stoichiometrically explicit models results in qualitatively different and realistic predictions about the resulting dynamics.

Stoichiometric models incorporate both food quantity and food quality effects in a single framework, appear to stabilize predator–prey systems while simultaneously producing rich dynamics with alternative domains of attraction and occasionally counterintuitive outcomes, such as coexistence of more than one predator species on a single-prey item and decreased herbivore performance in response to increased plant growth rate.

Stoichiometric theory has tremendous potential for both quantitative and qualitative improvements in the predictive power of mathematical population models in the study of both ecological and evolutional dynamics.

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Insights into cell invasion in development and disease

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A simple overview of the development of the gastrointestinal tract will be given. In particular, the migration of neural crest (NC) cells is necessary for the growing gut to be populated with neural precursors that develop into a normal functioning nervous system. NCC migration failure is associated with a birth defect called Hirschsprung's disease. The interplay between cell migration, cell proliferation and gut growth are important to the success of the NCC cell colonization process. We have developed a population-scale mathematical model for basic rules governing NC cell invasive behaviour incorporating the important mechanisms. The model predictions were tested experimentally. Mathematical and experimental results agreed. The results provide an understanding of why many of the genes implicated in Hirschsprung's Disease influence NC population size.

An approach of TilingArray Signal Identification Pipeline based on Classification with Bagging and Boosting

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Abstract:

Genomic large-scale tiling array has become a popular technology for exploring transcriptional activity of large genome regions in an unbiased fasion. Several appoaches using tiling arrays have been developed for identifying genomic active regions over last few years. They were introduced by Kapranov et al(2002), Kampa et al(2004), Bertone et al(2004), Schadt et al(2003). Some of these methods such as pseudo-median threshold maxgap/minirun(Kampa), sliding-window PCA with MD(schadt) include important parameters need to be decided manually. Although another HMM appoach advanced by JiangDu has the advantage of not using any additional parameters, it can't avoid ~40% error rate within the training set. Here we propose a novel signal identification pipeline based on classification that doesn't apply any parameters manually determined. Moreover, a boosted bagging noise filter is built for weeding out sample errors in original traning set. Adaboost with base learner CART ends up with showing transcribed and untranscribed probes. This pipeline is made up of three main steps- sample selection, noise filtering and signal identification.

In the first step, training samples are selected in lots of arrays. It follows the rule that the selection scheme could pick up both active and unactive proes in one array according to cy3 and cy5 intensities for a certain tissue. So maximum entropy algorithm is used to accomplish the job. For seleting the training set, validated knowledge of gene annotation has been considered, only the probes located in annotation have the opportunity to be hit. Any probe in the selected training set reside in exon of annotation would be denoted as transcribed, in intron reversely would be labeled with untranscribed. But this is not always true in some tissue or cell line. Mislabeled instances exit in the original traning sample, which can be detected by hybridization intensities of some tissue or cell line. The boosted bagging filter in the second step applys boosted bagging with CART method to count the error rate for each probe in iterations. This step filters about 45% mislabeled data, which significantly improve the quality of training set. The final step with classification CART invoveled in Adaboost marks probes of all arrays into transcribed or untranscribed. Tests revealed the pipeline is effective and very sensitve.

The pipeline differs from any clue of those statistical methods and adopts machine learning ensemble algorithms to improve the accuracy of signal identifying based on intensities and gene annotation.

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PREDATOR-PREY MODELS ON NON COINCIDENT SPATIAL DOMAINS

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When it comes to invasion and persistence of alien species it is often desirable to get rid of unwelcome species, e.g., predators, to protect naive native species. In spatially heterogeneous environments it may be quite difficult to devise efficient control methods to eradicate invading alien species while it may turn out to be possibly easier to locally reduce more accessible prey species densities below a suitable threshold yielding predator extinction.

We consider a spatially discrete deterministic mathematical model made of three patches, a first one occupied by both species, a second one hostile to predators occupied by prey only and a third one, a refuge for predators, occupied by predators only. Prey can disperse between their two favorable patches and so do predators. The biomass of captured prey in the first patch is distributed over patches predators are living in. A threshold is calculated from a stability analysis of the Jacobian matrix to the ODEs system evaluated at the predator-free state.

A spatially continuous model is derived yielding a set of reaction-diffusion equations posed on non-coincident spatial domains, Ω_u for predators and Ω_v for prey, with suitable initial nonnegative data and no-flux boundary conditions. The biomass of captured prey in $\Omega_u \cap \Omega_v$ is then distributed over Ω_u using an integral operator. Control methods to eradicate predators can be implemented upon locally harvesting/removing either species from small subdomains of either Ω_u or Ω_v. Their feasibility is then assessed by calculating suitable eigenvalues.

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Key words and phrases. predator-prey systems, non coincident spatial domains.

INTRINSIC AND EXTRINSIC NOISE IN GENE EXPRESSION

JINZHI LEI

Stochasticity is one of the most important properties in gene expression. The noises are originated from two sources, thermal fluctuation that inherent to the system(intrinsic noise), and variability in factors that are external to the system(extrinsic noise). We develop stochastic model to integrate the two sources of noise into a unify mathematical model through which the analytic expressions of stationary fluctuations in the number of protein molecules is obtained. Our results show that extrinsic noises can result to additional extrinsic fluctuation, correlation between the intrinsic noise and extrinsic noise, modification of the time averaging of transcription and translation, and amplification of the overall fluctuation. Robustness in gene expression under noisy condition is studied quantitatively. We find that reducing the fluctuation in the degradation rates of mRNA and protein are particular important to achieve good robustness. Furthermore, translational efficiency, gene copy number and feedback regulation have to be modulated properly according to the noisy condition to reduce the overall fluctuation in gene expression. These results indicate that robust property in gene regulation is a consequence of the regulation structure which is noise dependent, and does not require the fine-tuning of parameters.

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Key words and phrases. Gene expressino, Stochasticity, Robustness, Chemical Langevin equation, Feedback regulation.

THE EFFECT OF CONSTANT AND PULSE VACCINATION ON SIS EPIDEMIC MODELS INCORPORATING MEDIA COVERAGE

YONGFENG LI AND JINGAN CUI

A SIS epidemic model incorporating media coverage is presented in this paper. The dynamics of this disease model under constant and pulse vaccination are analyzed. First, stability analysis of the model with constant vaccination shows that the disease free equilibrium is globally asymptotically stable if the basic reproduction number is less than one, and the endemic equilibrium is globally asymptotically stable if it exists. Second, we consider the impulsive vaccination. Using the discrete dynamical system determined by the stroboscopic map, we obtain the exact periodic infection-free solution is globally asymptotically stable under some condition, we also show that the disease is permanent. Furthermore, by bifurcation theory we obtain the existence of a positive periodic solution. In order to apply vaccination pulses frequently enough so as to eradicate the disease, the threshold for the period of pulsing, i.e. τ_{max} is shown. Our theoretical results are confirmed by numerical simulations. The effectiveness of constant and pulse vaccination policies are compared.

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Key words and phrases. Disease model, impulsive effect, media coverage, periodic solution, permanence.

A GRAPH THEORETIC TECHNIQUE FOR THE METHOD OF GLOBAL LYAPUNOV FUNCTIONS

MICHAEL Y. LI

We describe some recent work on the application of a well-known Lyapunov function of the form

$$V = \sum_{k=1}^{n} a_k(x_k - x_k^* \log x_k)$$

for establishing the global stability of an interior equilibrium $x^* = (x_1^*, \cdots, x_n^*)$ of n-dimensional models. We show how results in graph theory can be used with this class of Lyapunov functions to prove the uniqueness and global stability of the endemic equilibrium of multi-group and multi-stage epidemic models. This is joint work with Hongbin Guo and Zhisheng Shuai at the University of Alberta.

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ASYMPTOTIC PROPERTIES OF HIV-1 INFECTION MODEL WITH TIME DELAYS

DAN LI AND WANBIAO MA

Based on some important biological meanings and well known results (M.A. Nowak and C.R.M. Bhangam, *Science*, **272** (1996), 74-79; A.V.M. Herz, S.Bonhoeffer, R.M.Anderson, R.M. May and M.A. Nowak, *Proc. Nat. Acad. Sci.*, USA **93** (1996), 7247-7251; P.W. Nelson and A.S. Perelson, *Math. Biosci.*, **179**(2002), 73-94; R.V. Culshaw and S. Ruan, *Math. Biosci.* **165** (2000), 27-39; T. Kajiwara and T. Sasaki, *Suri Kaiseki Kenkyujyo Kokyuroku*, No.1432, Kyoto University, 2005, 172-177; K. Wang, G. Deng and A. Fan, *The Advance of Biomathematics*, Z. Lu and Y. Zhou (Eds.), Science Press, Beijing, 2006, 58-73), a class of more general HIV-1 infection model with time delay is proposed. In the HIV-1 infection model, time delay is used to describe the time between infection of a uninfected target cells and the emission of viral particles on a cellular level. Then, the effect of time delay on stability of the equilibria of the HIV-1 infection model has been studied and sufficient criteria for local asymptotic stability of the infected equilibrium and global asymptotic stability of the viral free equilibrium are given.

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Key words and phrases. HIV-1 infection, time delay, stability.

ON THE DYNAMIC BEHAVIOR OF FIFTH-ORDER NONLINEAR DIFFERENCE EQUATION

DONGSHENG LI AND PINGPING LI

Nonlinear difference equations of order greater than one are very importance in application. Such equations also appear naturally as discrete analogues and as numerical solutions of differential and delay differential equations which model various diverse phenomena in biology, ecology, physiology, physics, engineering and economics. In this paper we consider the rule of trajectory structure for a kind of fifth-order rational difference equation, that is $x_{n+1} = \frac{F(x_n,x_{n-1},x_{n-3},x_{n-4})}{G(x_n,x_{n-1},x_{n-3},x_{n-4})}, n = 0, 1, \cdots$, where the functions

$$F(x,y,z,w) = x^u y^v + x^u z^k + x^u w^j + y^v z^k + y^v w^j + z^k w^j + x^u y^v z^k w^j + 1 + a,$$

$$G(x,y,z,w) = x^u + y^v + z^k + w^j + x^u y^v z^k + x^u y^v w^j + x^u z^k w^j + y^v z^k w^j + a,$$

the parameters $a \in [0, +\infty)$, $u \in (0, 1]$, $v, k, j \in (0, +\infty)$, and the initial values $x_{-4}, x_{-3}, x_{-2}, x_{-1}, x_0 \in (0, +\infty)$. The rule for the trajectory structure of any solution of the equation is as follows.
I. The solution is either eventually trivial or;
II. The solution eventually nontrivial and further either
II-1. The solution is eventually positive non-oscillatory or;
II-2. The solution is strictly oscillatory and moreover, the successive lengths for positive and negative semi-cycles occur periodically with prime period 31 and in a period the rule is

$$4^+, 2^-, 1^+, 1^-, 1^+, 1^-, 1^+, 1^-, 3^+, 1^-, 1^+, 2^-, 2^+, 3^-, 1^+, 5^-.$$

The positive equilibrium point of equation (1) is a global attractor of all its solutions.

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Key words and phrases. Rational difference equation; Trajectory structure rule; Periodicity; Global asymptotic stability; Semi-cycle length.

INCLUSIVE COMPOSITE INTERVAL MAPPING OF QUANTITATIVE TRAIT GENES

HUIHUI LI, ZHONGLAI LI, GUOYOU YE, AND JIANKONG WANG

Traditional composite interval mapping (CIM) proposed by Zeng (1994) is one of the most commonly used methods for mapping quantitative trait locus (QTL) with populations derived from biparental crosses. However, the algorithm used by CIM can not completely ensure that the effect of QTL at current testing interval is not absorbed by the background marker variables, and may result in biased estimation of the QTL effect. In addition, different background marker selection methods may give very different mapping results (Li et al. 2007a), and the nature of the preferred method is not clear. CIM cannot be extended for mapping epistasis (Zeng et al. 1999).

Under the assumption of additivity of QTL effects on the phenotype of a trait in interest, the additive effect of a QTL can be completely absorbed by the two flanking marker variables (Zeng 1994; Li et al. 2007a), and the epistatic effect between two QTL can be completely absorbed by the four marker-pair multiplication variables between the two pairs of flanking markers (Li et al. 2007b). Based on this property, we proposed a statistical method for QTL mapping, which was called inclusive composite interval mapping (ICIM) (Li et al. 2007a, 2007b). Marker variables were considered in a linear model in ICIM for additive mapping, and both marker variables and marker-pair multiplications were simultaneously considered for epistasis mapping.

Two steps were included in ICIM. In the first step, stepwise regression was applied to identify the most significant regression variables in both cases but with different probability levels of entering and removing variables. In the second step, a one-dimensional scanning or interval mapping was conducted for mapping additive and a two-dimensional scanning was conducted for mapping digenic epistasis.

For additive mapping, ICIM retains all advantages of CIM over interval mapping, and avoids the possible increase of sampling variance and the complicated background marker selection process in CIM (Li et al.

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Key words and phrases. QTL mapping, additive effect, Epistasis, Inclusive composite interval mapping, EM algorithm.

2007a). Extensive simulations using different genomes and various genetic models indicate that ICIM has increased detection power, reduced false detection rate and less biased estimates of QTL effects compared to CIM in additive mapping (Li et al. 2007a). Extensive simulations also show that ICIM is an efficient method for epistasis mapping, and QTL epistatic networks can be identified no matter whether the two QTL have any additive effects (Li et al. 2007b).

We also compared ICIM with the Bayesian mapping methods proposed by Yi et al. 2003a and 2003b, the results of ICIM were very similar (Li et al. 2007a, 2007b). But ICIM is much simpler in principle and faster in computation. It required less than 5 minutes for ICIM to complete the 100 simulation runs in a personal computer.

The software implementing the additive and epistasis mapping of ICIM is called IciMapping and is available from
http://www.isbreeding.net/software.html.

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DYNAMICAL BEHAVIOR OF AN EPIDEMIC MODEL WITH COINFECTION OF TWO DISEASES

LI JIANQUAN, MA ZHIEN, AND MA RUNNIAN

In this paper, we have formulated a simple epidemiological model with two diseases that can coinfect a single host. The first disease was assumed to be chronic, the second one is acute. For infectives infected only by the first disease, we introduce the age of infection. For these two diseases, we obtained their reproduction numbers, respectively, and established conditions for the existence and stability of the disease-free equilibrium, the boundary equilibrium, and the positive (coexistent) equilibrium.

For the infectious individuals infected only by the first disease, when some transfer rates depend on the age of infection, the corresponding models is governed by partial differential equations(PDE), we gave a sufficient condition for the existence of positive equilibrium, and its stability is determined by a transcendental equation; when all the associated rates are independent of the age of infection, the corresponding models is an ordinary differential equations(ODE), we obtained the complete results on dynamics, found that the coexistent equilibrium of two diseases is globally stable if there exists, and that the boundary equilibrium is globally stable if it is locally stable. And, we find that there is a difference between PDE and ODE models.

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Key words and phrases. epidemic model, age of infection, equilibrium, stability.

The abstract of Global Stability of an SEIR epidemic model with nonlinear incidence rates

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Main result: The SEIR model with nonlinear incidence rates $\lambda I^p S^q$ in epidemiology is further studied.

Firstly , if $p=2, q=1$ and $\bar{\sigma}=\frac{a\alpha\beta^2}{4(\alpha+\beta)^2}<1$,there is only a disease-free equilibrium $P_0(1,0,0)$ which is globally asymptotically stable in the interior of T.

Secondly, if $\bar{\sigma}=\frac{a\alpha\beta^2}{4(\alpha+\beta)^2}=1$, We discuss the existence of special periodic orbits under the positive invariant B^1, Analysis the trajectory in every sub-region in figure,we will get that the trajectory are spiring following

$$B_2 \to B_3 \to B_4 \to B_5 \to B_6 \to B_1 \to B_2 .$$

Besides,there may be periodic orbits. Because when some $t_0>0$ returns to $F \subset (B_1 \cap B_2)$,we can define a map: $\Phi: F \to F$ .Under theorem *Brouwer* ,there will be $\hat{q} \in F$, it wll make $\Phi(\hat{q})=\hat{q}$.

Thirdly: The trajectory of any nonconstant periodic solution to (2.1), if it exists, is asymptotically orbitally stable with asymptotic phase.

Finally: if $\bar{\sigma}=\frac{a\alpha\beta^2}{4(\alpha+\beta)^2}>1$, the system must yield Hopf bifurcation,steady switch phenomenon.

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Optimality Algorithm and Convergence of the Model for Microbial Continuous Fermentation

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Abstract: Based on the continuous time system and its discrete system of producing 1, 3-propanediol by microbial continuous fermentation, taking the zero of their optimality functions as the terminal criteria, the optimal algorithms are constructed, and the convergence of the algorithm is analysis. The validity of the model and the algorithm are shown by the examples.

Keywords: optimal algorithm, convergence, continuous fermentation.

ANALYSIS OF AN SIVS EPIDEMIC MODEL WITH PER CAPITA VACCINATION RATE INCREASING WITH THE PREVALENCE

XUE-ZHI LI, JING-WANG, AND MAIA MARTCHEVA

In this paper, We introduce an SIS epidemic model with vaccination. The susceptible population is subjected to a vaccination campaign with per capita vaccination rate $\Psi(I)$. We assume that the number of individuals vaccinated per unit of time may depend on the number of infected individuals. It it reasonable to assume that this function may be an increasing function of the number of infected individuals. Upon vaccination, individuals move to the vaccinated class where they are completely protected from the infections. However, the vaccination loses its protective properties with time and eventually vaccinated individuals become susceptible again. We call the time individuals spend in the vaccinated class vaccine-age and denote it by θ. The newly vaccinated individuals enter the vaccinated class $V(\theta, t)$ with vaccine-age equal to zero. The rate at which the vaccine wanes is denoted by $\alpha(\theta)$. The model consists of two ODE equations and one PDE equation. The existence and stability conditions for the disease-free and endemic equilibrium of this model are discussed.

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An Entropy-based Statistic for Genomic Association Study for QTL in Extreme Samples of Population

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Abstract: An entropy-based statistic has been proposed by Zhao et al. for genomic association study for disease-susceptibility locus. We extend this theory to quantitative trait and obtain an entropy-based statistic for association analysis of quantitative-trait locus (QTL) using extreme individuals in populations. We investigate the performance both from analytic and simulative point of view. In addition, a simulation study is performed on the basis of the haplotype frequencies of 10 SNPs of angiotensin-I converting enzyme (ACE) genes.

The effect of resource impulsive addition on species coexitence*

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Abstract

Community ecology aims at explaining biodiversity in terms of mechanisms underlying species coexistence. A key question in ecology is which factors control species diversity in a community. Plant community ecologists have shown much interest in the relationship between productivity and diversity. Diversity usually drops when fertilizer is added to a plant community. Using a resource competition model widely used in plankton ecology and plant ecology, we investigate the effect of resource periodic addition on the species competition, coexistence and diversity in the a plant community. The result show that resource impulsive addition not only induce the biodiversity to decrease, and there are rich dynamics that depend on the resource impulsive addition. such as bifurcation, quasi-periodic oscillation, etc.

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Analysis of a delayed predator-prey system with impulsive state feedback

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Abstract

A delayed dynamical system modeling a modified Leslie-Gower and Holling- type II schemes under state-dependent impulses is investigated. We analyze the boundedness of solutions by applying the comparison argument. Moreover, the existence and stability of semi-trivial solutions and positive period-1 solutions for small delay are discussed by using the invariant principle and the Poincare map. We also present some numerical simulation in detail. It is shown that chaotic solutions can be generated via a cascade of period-doubling bifurcations.

Dynamics OF Extended Schnakeberg Model

Jin-Guo Lian*

November 4, 2006

Abstract

We employ coincidence degree method to prove existence of T-periodic solutions in $\mathcal{D}$ for extended Schnakeberg model (which is a system of nonlinear, non-autonomous ordinary differential equations), where $\mathcal{D}$ is a strictly positively invariant region. Furthermore, Floquet theory is provided to analyze uniqueness of a T-periodic solution $x_0(t)$ in $\mathcal{D}$ and stability of $x_0(t)$ is presented.

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SERIES SOLUTION OF VAN DER POL'S EQUATION

HINA KHAN AND SHIJUN LIAO

An analytic technique, namely the homotopy analysis method (HAM), is employed to solve the non-linear Van der Pol's equation.

$$x'' + \epsilon(x^2 - 1)x' + x = 0,$$

with boundary condition

$$x(0) = x(T),$$

where $\epsilon \in [0, \infty)$. This equation serves as a basic model for the problems arising in different areas such as biology (nerve impulse), biochemistry and mechanical, electronic engineering etc. Unlike perturbation method the current approach doesn't depend upon any small parameters at all and thus is valid for more problems. Besides, it provides us with a simple way to ensure the convergence of solution series. The convergent series solution are given, which agree well with numerical results. This approach can be applied widely to solve nonlinear ODEs and PDEs in biology.

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Key words and phrases. Van der Pol's equation, Series solution, the homotopy analysis method.

Comparison Results for a kind of Impulsive Parabolic Equation with delay

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Abstract: The impulsive differential equations describe evolution processes which at certain moments change their state rapidly. In the mathematical simulation of such processes it is convenient to assume that these changes take place momentarily and the processes change their state by jump. Processes of such character are observed in numerous fields of science and technology(for example, in population dynamics,one may easily visualise situations in nature where abrupt changes such as harvesting, disasters and instantaneous stocking may occur). The wide possibility of applications determines the growing interest in impulsive differential equations. In this paper,for a semi-linear parabolic differential equations with impulsive and delay effects, we define its upper and lower solutions. By using the method of upper and lower solutions ,the existence and uniqueness of solutions are investigated.

Keywords: Impulsive parabolic equations with delay, upper and lower solution, existence-comparison theorem
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A STAGE-STRUCTURED PREDATOR-PREY MODEL WITH BEDDINGTON-DEANGELIS FUNCTIONAL RESPONSE

SHENGQIANG LIU AND JIANHUA ZHANG

We consider a predator-prey model of Beddington-DeAngelis type functional response with stage structure on prey. The time delay is the time taken from birth to maturity about the prey. The necessary and sufficient conditions for the permanence of predator as well as the global attractiveness criterion for the interior equilibrium and the axis equilibrium are obtained. Moreover, it is proved that the time delay will also "stabilize" the system.

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RESEARCH OF THE MULTIVARIATE STATISTICS ANALYSIS IN THE AURICULO-VENTRICULAR BLOCK

GUANGCHEN LIU AND MEI SONG

Objective: Auriculo-ventricular Block (AVB) is caused by the extended refractory period of the cardiac conduction system. According to the extent of the period, the AVB is divided into three categories: $I°$,$II°$, $III°$AVB, where the $III°$AVB is a complete block, the rest are incomplete. We try to study the clinical indexes of the AVB by the ECG, and find more effective techniques of the clinical diagnosis.

Method: 67 cases of the AVB ECG records are selected. The following indexes are collected from the 67 records respectively: gender, age, disease type, PR or QRS interval, atrial rate etc. Where the abbreviative notation is: gender (1-male; 2-women), disease type (1-myocarditis; 2-essential hypertension, coronary heart disease, corpulmonale; 3-rheumatic heart disease, rheumatic fever and diabetes; 4-others). Firstly, we find the classification of the above indexes according to the hierarchical clustering analysis, using the world famous statistics software SPSS. Then give the discriminant function and the effect analysis according to the stepwise discriminant analysis.

Result: (1) The computation shows that, all factors are classified into two categories: one is atrial rate, another one is the rest four indexes; (2) According to the stepwise discriminant analysis, the following three indexes are screened out as combined indexes of the discrimination function: the disease type, the PR or QRS interval and atrial rate, which coincides with the results of the clustering analysis. Finally the check computation shows that, the overall discrimination sensitivity is 74.6%, and the discriminant sensitivities of the $I°$,$II°$,$III°$AVB are 88.2%, 62.5%, 76.9%.

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Key words and phrases. the auriculo-ventricular blockthe PR intervalthe QRS interval; the clustering analysisthe stepwise discriminant analysis.

Conclusion: The combined indexes constituted by the disease type, the PR or QRS interval and atrial rate play an important role in the diagnosis of the AVB.

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Mathematical model to assess the contraception control of plateau pika (*Ochotona Curzoniae*)

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Abstract: A mathematical model with sexual structure was formulated to investigate the influence of contraception rates of two sexes on the dynamic of plateau pika population and to compare the difference between contraception control and lethal control with rodenticides. Contraception control has better effects than lethal control in both eliminating and depressing plateau pika population. The contraception rate of female is more important than that of the male. So, more attention should be paid to it when applying contraception control to plateau pika population.

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1991 Mathematics Subject Classification: 34D05, 92D25
Key words and phrases: contraception control, plateau pika, sexual structure, lethal control, mathematical model

DISEASE TRANSMISSION INVOLVING TRAVEL

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Abstract: A delayed SIS model is developed to describe the effect of transport-related infection, and the basic reproduction number R_0 is calculated. It is shown that this number characterizes the disease transmission dynamics; if $R_0 < 1$, there exists only the disease-free equilibrium which is globally asymptotically stable; and if $R_0 > 1$ then there is a disease endemic equilibrium and the disease persists. The dependence of R_0 on the transport time and the infection during transportation is analyzed and some numerical results are provided.

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1991 *Mathematics Subject Classification.* 92D,34K.

Key words and phrases. Transport-related infection; Stability; Delay; Permanence.

MODELLING AND ANALYSIS OF CONTINUOUS AND IMPULSIVE PEST CONTROL STRATEGIES

KAIYUAN LIU, FENGMEI TAO, AND LANSUN CHEN

In this paper, two mathematical models concerning continuous and impulsive pest control strategies were proposed, respectively. In the case in which a continuous control is used, it is shown that the model admits a globally asymptotically stable positive equilibrium under appropriate conditions which involve parameter estimations. As a result, the global asymptotic stability of the unique positive equilibrium is used to establish a procedure to maintain the pests at an acceptably low level in the long term. In the case in which an impulsive control is used, it is observed that there exists a globally asymptotically stable susceptible pest-eradication periodic solution on condition that the amount of infective pests released periodically is larger than some critical value. When the amount of infective pests released is less than this critical value, the system is shown to be permanent, which implies that the trivial susceptible pest-eradication solution loses its stability. Further, the dynamical behavior of the system with impulsive control is also studied by means of numerical simulation. Finally, a brief discussion is given.

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Key words and phrases. Impulsive control; Continuous control; Susceptible pests; Infective pests; Permanence; Extinction .

THE ANALYSIS OF AN HIV/AIDS MODEL WITH VACCINATION

LIU MAOXING AND JIN ZHEN

We present an ordinary differential equation mathematical model for the HIV/AIDS epidemic model with vaccination. The dynamic of this epidemic model is analyzed, and an optical vaccine efficacy is put forward. We define a reproductive number, R_0, for the number of secondary cases that one infected individual will cause through the duration of the infectious period. We find that the disease-free equilibrium is locally asymptotically stable when $R_0 < 1$ and unstable when $R_0 > 1$. We prove the existence of at least one endemic equilibrium point for all $R_0 > 1$. In this paper, based on the center manifold theory and computational method, we give that a static bifurcation occurs at the disease free equilibrium of the model and the codimension of its bifurcation is equal to one. It gets that the system has an unstable structure. Theoretical results show that making the environment different plays an important role in controlling the disease, and under a planned control the number of the HIV infected and the AIDS individuals will be eliminated.

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Key words and phrases. HIV/AIDS, Vaccination, Stability, bifurcation.

AN SVIR EPIDEMIC MODEL WITH IMPULSIVE VACCINATION

XIANNING LIU AND YASUHIRO TAKEUCHI

Vaccination is important for the elimination of infectious diseases. To finish a vaccination process, doses usually should be taken several times and there must be some fixed time intervals between two doses. Hence it is convenient to consider the pulse vaccination strategy (PVS) and model this process via impulsive differential equations. We establish an impulsive SVIR model by considering that vaccination is done impulsively and vaccinated individuals may not have the immunity against disease immediately. The effect of vaccination on the elimination of disease is studied by analyzing the disease free periodic solution and disease persistence of the system.

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Key words and phrases. Vaccination, SVIR model, Pulse.

BIFURCATION OF PERIODIC SOLUTIONS OF A PERTURBED FOUR-DIMENSIONAL SYSTEM

XUANLIANG LIU, YONGQI LIU, XIAOYING MENG

Consider a non-hyperbolic periodic orbit of a four-dimensional system, assume that the periodic orbit is on an invariant surface of the four dimensional system, after a suitable perturbation, the non-hyperbolic periodic orbit can generate periodic orbits and double-period orbits. By using bifurcation methods and techniques, we obtain the sufficient conditions for the existence of periodic orbits and double-period orbits of the perturbed four dimensional system.

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Key words and phrases. bifurcation, periodic orbit, double-period orbit.

1 Research progress on intelligent virtual life's simulation

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Life simulation is the dream that people have been pursuing all the time. The development of artificial intelligence has promoted the advancement of traditional computer character animation. This paper presents a review on intersection between artificial life and character animation, and introduces some key concepts of artificial life and character animation. In order to create an intelligent virtual character, a cognitive model with perception, emotion, learning should be set up for a virtual character.

2 A mathematics model of virtual character's emotion

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Moding 3D virtual characters is a challenging branch in computer science and social science. A believable 3D character should be provided with emotion and perception. In general, a virtual character is regarded as an autonomous agent with sense, perception, behavior and action. An emotion model of 3D virtual characters on the basis of psychology theory is presented in this paper. A 3D virtual characters has internal sensor and perception for external stimulus, and it can express emotion autonomously in real time. Firstly, architecture of a virtual character is set up by cognitive model, Secondly, emotion class is set up by OCC and Plutchik's emotion theory; Thirdly, some new concepts about emotion are presented with a general mathematical model which is relation among emotion, stimulus, motivation variable, personality variable. Fourthly, a perception model of 3D characters by Gibson's theory is introduced. As a result, an emotional animation demo sys-tem of 3D virtual character is implemented on PC.

Computing the firing time statistics for the periodically driven leaky integrate-and-fire neuron model

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Abstract

The leaky integrate-and-fire (LIF) model is one of the most widely used spiking neuron models. In the LIF model neurons are modelled as threshold devices that receive a deterministic input current which charges the membrane of a neuron like a leaky capacitor. When the potential across the membrane reaches a threshold, a spike is fired. After the spike, the membrane potential is reset to a resting value. In between two spikes, the membrane potential of the LIF neuron is governed by the Ornstein-Uhlenbeck process (abbreviated as OU-process) with the threshold as an absorbing boundary. The first passage time density (FPTD) of the OU-process corresponds to the distribution function of the interspike intervals of this neuron model. Furthermore, with the addition of a periodic driving force, the stochastic firing process becomes nonstationary and escalates the complexity of the problem.

Unfortunately, despite the importance and wide applications of the OU-process, explicit analytic closed-form solutions to such a first passage time problem are not known. So far three representations of analytical nature have been obtained for the first passage time distribution function (FPTDF) of an OU-process through a constant threshold. The first one is based on an eigenfunction expansion involving zeros of the parabolic cylinder functions, the second one is an integral representation involving some special functions, and the third one is given in terms of a functional of a three-dimensional Bessel bridge. Nevertheless, these three representations are valid for an OU-process with constant model parameters only.

In this paper we apply the method of images to derive the closed-form formula for the FPTD of a periodically driven LIF neuron model to a parametric class of time-dependent boundaries. The results are then applied to develop a simple, efficient and systematic approximation scheme to compute very accurate estimates of the FPTD through a constant threshold. This new approach can also provide very tight upper and lower bounds (in closed form) for the exact FPTD. The FPTD in turn provides us the information of the firing time statistics for the periodically driven LIF neuron model. This new approach is novel because, unlike previous approximate analytical attempts, our approximation scheme not only goes beyond the linear response and weak noise limit, but it can also be efficiently improved to yield the exact results in a systematic manner. Furthermore, it is straightforward to extend our approach to study the more general case of a deterministically time-dependent threshold, e.g. a decaying threshold which mimics the effect of an afterhyperpolarization observed in many neurons.

EVOLUTION OF CONDITIONAL DISPERSAL

YUAN LOU

A Lotka-Volterra reaction-diffusion-advection model for two competing species in a heterogeneous environment is investigated, in connection with the evolution of conditional dispersal strategies. The two species are assumed to be identical except their dispersal strategies. Though both species disperse by random diffusion and advection along environmental gradients, one species has much stronger biased movement than the other one. The species with stronger biased movement behaves like a specialist as it mainly pursues resources at places of locally most favorable environments. The other species has a rather balanced dispersal strategy and can be regarded as a generalist. It is shown that at least two scenarios can occur: If the generalist's biased movement rate is relatively smaller than its own random movement rate, then both species can coexist; If its biased movement is relatively stronger than its random movement, then the generalist is always the winner, regardless of the initial condition. These results may have applications to the evolution of conditional dispersal, e.g., they seem to suggest that selection is against large advection and that an intermediate biased movement rate may evolve.

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Key words and phrases. Evolution of dispersal, reaction-diffusion-advection, spatial heterogeneity, competition.

A dynamical system with discontinuity and time delay - an application on networks

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Abstract

Since the 1950's, there has been much effort devoted to using a neural network as an associative memory model. Some of these earlier works are simpler models such as the linear associator that can be solved by Hebbian Rule, or by Generalized inverse method. Due to the limit capacity of the linear models, researchers introduced various nonlinear associative memories to remedy the problem caused by the linear associative memory models. One of such nonlinear models is the Hopfield model which was introduced by Hopfield in 1982 and became a popular model in dynamical systems since then. This paper provides a modification of the Hopfield model considering memory delay and the jump discontinuity that can happen in brain memory.

Suppose that in a network every unit is connected each other and the connections are symmetric. This means that if the connection weights from unit i to unit j is denoted by w_{ij} then $w_{ij} = w_{ji}$. Assume that $w_{ij} \geq 0$ for all $i, j = 1, ..., n$, and that for unit i, the membrane capacitance is denoted by C_i, the transmembrane resistance by R_i, the instantaneous transmembrane potential by u_i. Also, we use I_i to denote the external input current and y_i the output potential. Then the continuous Hopfield model is a system of nonlinear differential equations as follows:

$$\sigma_i \frac{du_i}{dt} = \sum_{j=1}^{n} w_{ij} y_j - u_i + I_i R_i, \quad i = 1, 2, ..., n \tag{1}$$

Define an energy function

$$E = -\frac{1}{2} \sum_i \sum_j w_{ij} y_i y_j - \sum_i I_i y_i + \sum_i \frac{1}{R_i} \int_0^{y_i} g_i^{-1}(y) dy. \tag{2}$$

Applying the symmetry of the weight functions, one gets

$$\frac{dE}{dt} = -\sum_i C_i \frac{dy_i}{dt}\frac{du_i}{dt} = -\sum_i C_i (g_i^{-1}(y_i))' \left(\frac{dy_i}{dt}\right)^2.$$

This shows that the Hopfield network is stable and that the steady state is an attractor.

In the original Hopfield model, the matrix $[w_{ij}]$ is a constant matrix and therefore, the right hand side of the system of equations is continuous. Thus, the Holpfield model is a smooth dynamical network. However, the real neuron system may not always perform smoothly in the brain. The dynamical system may be non-smooth. A simple case is that the connection weight conductance w_{ij} is not a constant. That is that w_{ij} is a function of t and it varies depending on the difference u_i and u_j. We may assume that if u_i is greater than u_j then the rate of change on u_i would be dragged down. This suggests that we shall replace the weight connection w_{ij} by a function of t. One of such networks is the model proposed by Kennedy and Chua, in 1998, described as follows

$$x_i^{'} = -\frac{\partial \phi(x)}{\partial x_i} - \sum_{j=1}^{n} \nu_j \frac{\partial f_j(x)}{\partial x_i}, i = 1, ..., n$$

where $\nu_j = q_j(f_j(x))$, $j = 1, 2, ..., n$, and $x = (x_1, x_2, ...x_n)$. In this model, the functions $\phi(x)$ and $f_j(x)$ are in $C^2(R^n)$, which are later generalized as regular in R^n. The nonlinear resistors g_j for $j = 1, 2, ..., n$, are assumed to be the piecewise-linear function

$$q_j(\rho) = q(\rho) = \begin{cases} 0, \rho \geq 0 \\ \frac{1}{f}\rho, \rho < 0. \end{cases}$$

The the energy function

$$E(x) = \phi(x) + \sum_{j=1}^{n} \int_0^{f_j(x)} q(\rho) d\rho$$

is considered. It then follows that $E \in C^1(R^n)$. It can be shown that

$$\frac{dE(x(t))}{dt} = -||x'(t)||^2.$$

This gives that the equilibrium is stable.

This paper modified the Kennedy-Chua model by adding the time-delay terms in the differential equations. Assume the time-delay term is similar to the Hopfield

model and occurs in connections between the two neurons. The modified model would have the following form

$$x_i^{'} = -\frac{\partial \phi(x)}{\partial x_i} - \sum_{j=1}^{n} \nu_j \frac{\partial f_j(x)}{\partial x_i} + \sum_{j=1}^{n} \alpha_{ij} g_j(x_j(t-\tau_{ij}))$$

where $0 \leq \tau_{ij} \leq \tau, 0 < \alpha_{ij} < \alpha$ and g_j is a function similar to g as in Hopfiled model. The paper will study the existence of the solutions with the initial conditions $x(s) = h(s)$ for $s \in (-\tau_{ij}, 0)$ with given h. The continuity of the solutions will be given. Finally, The energy function

$$E(x(t)) = \phi(x) + \sum_{j=1}^{n} \int_0^{f_j(x)} q(\rho) d\rho - n \sum_{j=1}^{n} {\alpha_{ij}}^2 \int_0^{t-\tau} g_j^2(x_j(s)) ds, i = 1, 2, ..., n$$

is going to be utilized to show that

$$\begin{aligned} \frac{dE}{dt} &= (-x_i' + \sum_{j=1}^{n} \alpha_{ij} g_j(x_j(t-\tau_{ij}))x_i' - n \sum_{j=1}^{n} {\alpha_{ij}}^2 g_j^2(x_j(t-\tau_{ij})) \\ &\leq -\frac{1}{2}||x_i'||^2 - \frac{n}{2} \sum_{j=1}^{n} \alpha_{ij}^2 g_j^2(x_j(t-\tau_{ij})) < 0 \end{aligned}$$

And the stability of the system will be studied.

Analysis of Eco-epidemiology Model with Ratio-dependent Response Function

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Abstract: In this paper, a ratio-dependent model with disease in the prey is formulated and analyzed. By mathematical methods, we get the boundness of solutions, persistence and global stability. We also get that Hopf bifurcation may occurs provided some conditions. We obtain the formula of " basic reproductive ratio " in epidemic theory. At last we simulatr each case and discuss the results we get.

Keywords: Eco-epidemiology; Boundness; Persistence; Bifurcation; Global stability.

OPTIMAL HARVESTING PROBLEM FOR AN AGE-DEPENDENT n-DIMENSIONAL COMPETING SYSTEM WITH DIFFUSION

ZHIXUE LUO

In this work, optimal harvesting policy for an age-dependent and spatial diffusion n-dimensional competing species is discussed. The existence and uniqueness of non-negative solution to the system are investigated by using the fixed point theorem. The existence of optimal control strategy is discussed and optimality conditions are obtained. Our results extend some known criteria.

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Key words and phrases. Diffusion, age-dependence, optimal control, the maximum principle.

Coloring the Mu Transpososome

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Abstract:
Background:
Tangle analysis has been applied successfully to study proteinswhich bind two segments of DNA and can knot and link circular DNA. We show how tangle analysis can be extended to model any stableprotein-DNA complex.
Results:
We have developed a computationalalgorithm to find the topological conformation of DNA bound within aprotein complex. The algorithm uses an elementary invariant fromknot theory called colorability to encode and search for possible A conformations. We apply this algorithm to analyze theexperimental results of Pathania, Jayaram, and Harshey (Cell 2002). We show that the only topological DNA conformation bound by Mutransposase which is biologically likely is the five crossingsolution found by Pathania et al(although otherpossibilities are discussed).
Conclusions:
Our algorithm can be used to analyzethe results of the experimental technique described in Pathania et aln order to determine the topological conformation of DNA bound within a stable protein-DNA complex.

Effects of time delay on two neurons interaction Morris-Lecar model

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Abstract Time delay is a natural factor arising in neurons models, since the signals take time during their transmission from pre-synaptic to post-synaptic of the neurite. The effects of time delay on two neurons interaction Morris-Lecar model are investigated. It is assumed the two neurons are coupled via gap junction. Time delay leads the both neurons to quiescent states though the simple neuron is chaotic. The complex firing behavior is induced as the parameter values cross the Hopf bifurcation curves. Complete synchronization and imperfect lag synchronization are also detected as the parameter values vary.

Qualitative Analysis of a Chemostat Model with Inhibitory Exponential Substrate Uptake and a Time Delay

Qinglai Dong[1] and Wanbiao Ma[2] .

It is well-known that the Chemostat dynamical model, which may be viewed as a laboratory model of a simple lake with continuous stirring, is of both ecological and mathematical interest since it is the most simple idealization of a biological system where the mathematics is tractable, the parameters are measurable, and the experiments are reasonable. Recently, the studies of the chemostat dynamical models with or without time delays and their experimental verifications of the match between theory and experiments have received a great deal of attention. Many modifications such as incorporating competition, food chain, periodic input and output etc are performed to describe the phenomena vividly. The studies include stability, the existence of the periodic solutions, persistence, competitive exclusion and bifurcations etc. In this paper, by using stability theory of delay differential equations and Liapunov-LaSalle invariant principle etc, we consider the following problems for a class of Chemostat dynamical model with inhibitory exponential substrate uptake and a time delay. A detailed theoretical analysis for the existence of equilibria, boundedness of the solutions and the local and global stability of the equilibria are carried out. Furthermore, numerical simulations are also performed to illustrate the applications of the results.

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PERMANENCE AND GLOBAL STABILITY IN A IMPULSIVE LOTKA-VOLTERRA $N-$SPECIES COMPETITIVE SYSTEM WITH BOTH DISCRETE DELAYS AND CONTINUOUS DELAYS

XINZHU MENG AND LANSUN CHEN

In this paper, we formulate a robust impulsive Lotka-Volterra $n-$species competitive system with both discrete delays and continuous delays. Our results in this paper indicate that under the appropriate linear bounded impulsive perturbations, the impulsive delay Lotka-Volterra system remains the original permanence and globally asymptotical stability of the nonimpulsive delay Lotka-Volterra system. We show that the conditions for the permanence and globally asymptotical stability of the system depend on time delays, so, we call it "profitless".

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Key words and phrases. Permanence; Impulsive effects; Lotka-Volterra system; Time delays; Globally asymptotical stability.

PREDICTING THE SIZE AND PROBABILITY OF AN EPIDEMIC IN A NETWORK WITH HETEROGENEOUS INFECTOIUSNESS AND SUSCEPTIBILITY

JOEL C. MILLER

We analytically address disease outbreaks in large, random networks with heterogeneous infectivity and susceptibility. Initially a single node is infected, following which a large-scale epidemic may or may not occur. We use a generating function approach to study how heterogeneity affects the probability that an epidemic occurs and, if one occurs, its attack rate (the fraction infected). The probability of an epidemic is highest if infectivity is homogeneous and lowest if the variance of infectivity is maximized. Similarly the size of an epidemic is maximized by homogeneous susceptiblity and minimized when its variance is maximized. We confirm our theoretical predictions by simulation. Our results have implications for control strategy design and identification of populations at higher risk from an epidemic.

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A MATHEMATICAL ANALYSIS OF THE GLOBAL DYNAMICS OF THE BASIC MODEL OF VIRUS INFECTION WITH APPLICATION IN ANTI-HBV INFECTION TREATMENT

LEQUAN MIN AND YONGMEI SU

The basic model of virus dynamics is widely used in the studies of virus infection dynamics. This model has two equilibrium points Q_1 and Q_2 which represent the host's complete recovery (uninfected steady-state) and persistent infection (epidemic steady-state), respectively. It is known that if the basic reproduce number R_0 of the model is less than 1 then Q_1 is locally stable and Q_2 is unstable; if the R_0 is larger than 1 then Q_2 is locally stable and Q_1 is unstable. Based on mathematical analysis and the LaSalle's invariant principle, this paper figures out an attract domain D in R^3, and proves that if $R_0 < 1$, then every trajectory of the basic model starting in D will converges to the equilibrium point Q_1. This result implies the following facts

(1) Hosts with $R_0 < 1$ may be still healthy even they are infected by a lot of virus.
(2) Hosts whose reproduce number R_0 are less than 1 but very near to 1, they may carry virus for long time although they may not appear clinic symptoms and will recover completely.
(3) Hosts with $R_0 > 1$ may be infected by healthy virus carriers

Now we can understand why there are some unclear virus infections during epidemic periods. As applications, some hepatitis B virus infection examples are given.

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Key words and phrases. global attraction, mathematical model, virus dynamics, hepatitis B.

IMMUNO-EPIDEMIOLOGY: THE ROLE OF VIRAL-IMMUNE DYNAMICS IN DISEASE EPIDEMIOLOGY

SEYED M. MOGHADAS

Integration of epidemic models with regard to the within-host aspects of infectious mechanisms may be a key approach for future research in modelling of human viral diseases. In order to design effective control strategies, the micro-dynamics of viral pathogens in vivo must be linked to the macro-dynamics of disease spread in the population. In this talk, examples of such integration are presented that can be used to address important public health concerns regarding the potential benefits and limitations of control measures, including vaccination and antiviral therapy. The bridging of the two different scales of disease pathogenesis and epidemiology through mathematical models will allow for the creation of new perspectives in immuno-epidemiology.

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Key words and phrases. Epidemic models, viral dynamics, vaccination, antiviral therapy.

EFFECT OF DELAY ON TWO COMPETING ORGANISM IN A POLLUTED ENVIRONMENT

Debasis Mukherjee

Abstract

This paper concentrates on the study of delay effect on a chemostat type model of two competing organisms in the presence of toxicant. It is assumed that one of the competitors is affected by the toxicant while other detoxifies the toxicant. Stability of interior equilibrium point is discussed. Delay analysis has been carried out when the organisms are in coexistence, bistable and dominance respectively. Lastly the results are verified through computer simulation. Numerical simulation suggests that delay has a destabilizing effect.

CHAOTIC TRANSIENT DYNAMICS ON LOTKA-VOLTERRA PREDATOR-PREY SYSTEMS WITH TWO DELAYS

SHINJI NAKAOKA, KAZUYUKI AIHARA, TOSHIYUKI YAJIMA, YASUHIRO TAKEUCHI

A Lotka-Volterra predator-prey system with two delays is studied. In [1], it has already proved that the system is permanent for any value of time delays if and only if there exists a positive equilibrium. In [2], we have investigated the global dynamics of the system and showed that chaotic behaviors can be observed.

Here we present an interesting type of dynamics known as *chaotic transient dynamics* on our system; We observed situations that the qualitative behavior of solutions finally settles in a sustained oscillation after a long-term chaotic behavior. We implement numerical simulations to investigate transient chaotic dynamics by varying the ratio of time delays as a control parameter. The behavior of solutions is likely to settle in a simple oscillation when the time delay in the density dependence of predator is relatively large. In this case, predator species exhibits a sudden short-term population outbreak although it is at a low level of population size in almost time. Practically, species at a low level of population size for a long term is endangered of extinction due to demographic stochasticity. Transient chaotic dynamics and species extinction are discussed on our model.

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Key words and phrases. Transient dynamics; Transient chaos; predator-prey system; delayed density dependence; toxic inhibitory effects; virus dynamics; extinction risk;

COEXISTENCE OF EXPPLOITATIVE AND APPARENT COMPETITORS IN SOURCE-SINK METACOMMUNITIES

TOSHIYUKI NAMBA

In a heterogeneous environment composed of different habitat patches, it depends greatly on habitat heterogeneity and dispersal rates of populations whether two indirect (exploitative or apparent) competitors can coexist or not. I consider two models of metacommunities composed of two different patches. In the first model, two conumers sharing a common resource compete exploitatively, and in the second model two resources sharing a common natural enemy compete apparently. Since the environmental productivity or demographic rates are different between the two patches, a population size of either species becomes higher in one patch than in another patch. Therefore, if these two patches are connected through dispersal of populations, there appear source-sink habitat structures, with one patch exporting individuals and another patch importing them.

Interactions between competitors also influence the habitat structure. If a species is competitively inferior and excluded locally in a patch, then the patch is considered to be a sink for the species because it cannot persist in the presence of the superior competitor. However, it has recently been found that dispersal of populations between the patches can mediate coexistence of two indirect competitors even if both patches are sinks in the latter sense for one of the two species when they are isolated. I will talk about why this mechanism of coexistence can work and how it depends on the dispersal rates of the two competitors.

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Large-scale parallel motif discovery research and implementation

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Abstract

The sequencing of complete genomes from multiple organisms has revealed that most differences in organism complexity are due to elements of gene regulation that reside in the non protein coding portions of genes. A key step in understanding gene regulation is to identify the repertoire of transcription factor binding motifs (TFBMs) that form the building blocks of promoters and other regulatory elements. Identifying these experimentally is very laborious, and the number of TFBMs discovered remains relatively small, especially when compared with the hundreds of transcription factor genes predicted in metazoan genomes. In this paper, we study parallel solutions to the problem of large-scale motif discovery. We present the design and implementation of parallel Weeder algorithm and transplant paraMEME on DeepComp 6800 super computer at the Supercomputing Center, Computer Network Information Center, Chinese Academy of Sciences. Based on large-scale dataset, the performance of paraWeeder and paraMEME are analyzed. Finally, we present both grid computing service interfaces to paraWeeder and paraMEME that are able to carry out large-scale motif discovery with remarkable computational efficiency.

Key words: motif discovery; large-scale; parallel computing; paraWeeder; paraMEME

MODELLING BACTERIAL SWARMING

E.S. NORRIS AND J.P. WARD

Swarming is a term used to describe the rapid spread of bacterial colonies on a moist semi-solid substrate. The phenomenon is cell density dependent and usually occurs in response to low nutrient levels. Swarming plays an important part in many bacterial infections, including wound infections and septicaemia as well as lung infections in, for example, cystic fibrosis patients. The current project aims to develop an understanding of the processes involved in bacterial swarming with the eventual aim of using this knowledge to compare different treatment strategies. Our initial work involves developing a model of swarming bacteria constrained within a thin film. The equations describing the biological mechanisms determining the behaviour of the bacteria are coupled with the standard thin-film reduction of the Navier-Stokes equation (which describes the action of the biosurfactant on the fluid boundary). The initial results of this modelling will be presented, along with a comparison of these results with the available experimental data.

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Key words and phrases. bacteria, swarming, cell-signalling, chemotaxis.

Assessing Basic Control Measures, Antivirals and Vaccine in Curtailing Pandemic Influenza: Scenarios for the US, UK, and the Netherlands

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Abstract: Recurrent avian flu cases in humans, arising primarily from direct contact with poultry, in several regions of the world have prompted the urgency to develop pandemic preparedness plans worldwide. Leading recommendations in these plans include basic public health control measures for minimizing transmission in hospitals and communities, the use of antiviral drugs, and vaccination. This paper presents a mathematical model for the evaluation of the pandemic flu preparedness plans of the United States (US), the United Kingdom (UK) and the Netherlands. The model is used to assess single and combined interventions. Using data from the US, we show that hospital and community transmission control measures alone can be highly effective in reducing the impact of a potential flu pandemic. We further show that while the singular use of antivirals could lead to very significant reductions in the burden of a pandemic, the combination of transmission control measures, antivirals and vaccine gives the most ``optimal'' result. However, implementing such an optimal strategy at the onset of a pandemic may not be realistic. Thus, it is important to consider other plausible alternatives. An optimal preparedness plan is largely dependent on the availability of resources; and, hence, it is country--specific. We show that for antiviral interventions, countries with limited supplies should emphasize their use therapeutically (rather than prophylactically). However, countries with large antiviral supplies can achieve greater reductions in disease burden by implementing them both prophylactically and therapeutically. This study promotes alternative strategies that may be feasible and attainable for the US, UK and the Netherlands. It emphasizes the importance of hospital and community transmission control measures in addition to the timely use of antiviral treatment in reducing the burden of a potential flu pandemic. The latter is consistent with the preparedness plans of the UK and the Netherlands. Our results indicate that a single-intervention program based on the use of vaccination seems to have limited impact in comparison to that based on the use of antivirals.

ANALYSIS OF A PULSED PEST-CONTROL VIRAL DISEASE MODEL

GUOPING PANG AND LANSUN CHEN

Based on biological control strategy for pest management, we investigate a pest-control viral disease model with impulsive releasing the infected pests at different fixed times. By the Floquet theory, we know that there exists a stable pest-eradication periodic solution when the birth rate of pests is less than a threshold value. By use of standard techniques of bifurcation theory, we prove that above this threshold value there are periodic oscillations in the impulsive system. Furthermore, the bifurcation diagrams of the virus replication rate regarded as bifurcation parameter have shown that there exists complexity for the pulsed system including quasi-periodic oscillation, periodic doubling cascade and chaos.

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Key words and phrases. Viral disease model; Pulse; Infected pests; Bifurcation; Chaos.

DISTURBANCE-GENERATED NICHE-SEGREGATION IN A STRUCTURED METAPOPULATION MODEL

KALLE PARVINEN AND GÉZA MESZÉNA

In studying coexistence, which is maintained by local disturbances via a trade-off between fecundity and competitivity, we use the theory of structured metapopulations to consider the local- and metapopulation-scale dynamics on the same footing. Our study reveals that this kind of diversity, while certainly possible, is constrained by the requirement of partitioning of the continuum of patches with different population densities, i.e., patches of different ages. Considering disturbance-maintained diversity as a way of niche-segregation allows ecological theory to be consistent with the Darwinian picture that competition between the similar kinds drives evolution, while the decreased competition between the differing species allows them to coexist.

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Key words and phrases. Diversity, disturbance, niche, metapopulation.

ANALYSIS OF A SIR EPIDEMIC MODEL WITH SATURATION INFECTIOUS FORCE FOR TWO DIFFERENT VACCINATION AND TREATMENT STRATEGIES

PEI YONGZHEN AND CHEN LANSUN

Two different vaccination and treatment strategies in the SIR epidemic model with saturation infectious force are analyzed. With continuous vaccination and treatment, using Lassalle'theorem and Pioncare-Bendixon'trichotomy, it is obtained that disease free equilibrium and endemic equilibrium are globally asymptotically stable. Moreover, with pulse vaccination and treatment at different time, the dynamics of the epidemic model is globally investigated by using Floquet theory and comparison theorem of impulsive differential equation and analytic method. We obtain the conditions of global asymptotical stability of the infection-free periodic solution and permanence of the model. Numerical results show that the system the results which we obtain are right.

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Key words and phrases. Impulse, Vaccination, Treatment, Extinction, Permanent.

QUANTIFYING DYNAMIC CROSSTALK OF THE YEAST MATING, INVASIVE GROWTH AND STRESS-RESPONSIVE MAPK CASCADES

TAO PENG,XIUFEN ZOU* AND ZISHU PAN

A central question in cell and developmental biology is how signaling pathways maintain specificity and avoid erroneous cross-talk so that distinct signals produce the appropriate changes. Cells must have evolved mechanisms to maintain specificity in order to avoid unwanted responses to stimuli, while at the same time allowing the proper response to take place. In literature[1], the mathematical definition of specificity of very simple signaling networks was presented, and discuss several different insulating mechanisms to maintain specificity. In literature[2], two new measures of dynamic crosstalk, the intrinsic specificity and the extrinsic specificity, were introduced to analysis the interaction between the pheromone pathway and the filamentous growth pathway in yeast. In this study, we develop a full mathematical model of the yeast mating, invasive growth and stress-responsive MAPK cascades based on experimental data, and address issues of specificity in a concrete manner. From numerical simulations, we can get the following conclusions (1) When three pathways are responsive and stimulated, the HOG pathway inhibits the response of the pheromone pathway and the response of the filamentous growth pathway in terms of mitogen activated protein kinase activity and transcriptional activity. (2) In the Hog1 and Pbs2 mutant, when the HOG pathway is stimulated, but the pheromone pathway and the filamentous pathway are not stimulated, the high osmotic stress can stimulated the pheromone pathway and the filamentous pathway, but the level of the output is lower than the one when the HOG pathway is not stimulated. These results are consistent with both quantitative and qualitative data in the literature, so we can

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Key words and phrases. dynamic crosstalk, yeast,MAPK cascades;

acquire new insights into the integrated nature of three signaling pathways, and assess the relative contributions of the various mechanisms to specificity.

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A Recognition and Simulation Model for Ordinary Linear System with Java Implementation*

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ABSTRACT

Ordinary linear system is the most basic form for engineering and ecological systems. A simulation analysis on these kinds of systems will help us understand the behaviors and features of the system and predict the dynamic trend. Linearity of the system and system matrix should be recognized or determined. In this study some algorithms were developed to recognize the linearity and determine the system matrix. A Java model for ordinary linear system was developed, in which the linear regression was used to recognize linearity. It may be used to make dynamic simulation and prediction for ordinary linear system using the model. Stability of the system can also be computed and indicated in the model. This Java model included 6 classes and 1 html file, and can be run on various Java-enabled web browsers.

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MODELLING CULLING STRATEGIES TO ELIMINATE ANIMAL DISEASE

JOHN F. RAYMAN AND DR. STEPHEN A. GOURLEY

In the U.K., endemic bovine tuberculosis is a major problem for cattle farmers. It is widely believed (although not proved) that the disease is spread by badgers, a protected species, living in the same environment as the cattle. Badger culling trials have taken place with inconclusive results but great public outcry from conservationists.

We examine some simple culling models of a single animal species, incorporating both population and disease dynamics, on both a continuous and impulsive basis and where the culling is either fixed rate (removing a proportion of the population in unit time) or fixed yield (removing a fixed number of animals in unit time). We compare and contrast the results. We show that there are strategies where it is possible to remove the endemic disease without culling all the animal population while others cannot achieve this result without a population crash.

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Traveling Waves in Epidemic Models

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Abstract

In this talk, some classical epidemic models, such as Ross-Macdonald model, Kermack-McKendrik model, Kendall model, Diekmann-Thieme model, will be reviewed. Then the existence of traveling waves in some epidemic models described by reaction-diffusion systems will be demonstrated. Some specific problems, such as the transmission of rabies in fox population, spatial spread of malaria, geographic spread of leafminers, will be modeled and studied.

RICH DYNAMICS OF A PREDATOR-PREY MODEL WITH DISEASE IN THE PREY

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Abstract. In this paper, we have proposed a system of nonlinear differential equations as a predator-prey model with disease in the prey. Dynamical behaviours such as boundedness, stability, bifurcation et cetera of the model are studied. The effect of time-delay on the model is investigated. Computer simulations are carried out to illustrate our mathematical findings. It is discussed how these ideas illuminate some of the observed properties of real populations in the field and explores practical implications.

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PUBLIC GOODS GAMES WITH PROBABILISTIC PARTICIPATION: EVOLUTIONARY DYNAMICS AND SPATIAL EFFECTS

TATSUYA SASAKI, ISAMU OKADA, AND TATSUO UNEMI

The emergence and maintenance of cooperation by natural selection is an enduring puzzle in biology and social sciences. In social dilemmas, cooperators produce a common bene t at some cost to themselves while defectors exploit the bene t without costs. This results in ubiquitous con icts of interest between the individual and the community. Such situations generate a variety of game theoretical models e.g. the prisoner's dilemma, the snowdrift game and public goods games. An attempt at resolving the con ict of interest is voluntary public goods games. This allows individuals to avert the risk of unpromising public enterprises and hence changes compulsory interactions into voluntary participation. This leads to a cyclic dominance of cooperators(C), defectors(D) and loners(L) that do not participate and rely on a small but xed payo .

Here, we modify voluntary participation to continuous-entry type. In real life, decision of participation may not always be constant but rather like a stochastic variable. Our simple way for describing probabilistic participation is to change the three pure-strategies into the two mixed-strategies; $p_x\mathrm{C}+(1-p_x)\mathrm{L}$ and $p_y\mathrm{D}+(1-p_y)\mathrm{L}$. p_x and p_y are probability of participation in a single public goods game. We fully classify the phase diagram (p_x, p_y) into four basic evolutionary dynamics of social dilemma games, given by dominating defection, co-existence, dominaning cooperation and bi-stability. Moreover, in spatially extended individual-based simulations, depending on the cost-to-bene t ratio, adaptive dynamics of individual participation rate recover three typical patterns of spatial dilemma games, given by static compact clusters, traveling waves and local co-existence that often appear in the spatial snowdrift game.

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Key words and phrases. cooperation, social dilemmas, probabilistic participation, evolutionary game dynamics, public goods games, spatial games, individual-based simulation.

Mathematical Model for the Dynamics of Tuberculosis in Algeria

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Abstract

We present a deterministic model that describes the dynamics of tuberculosis in Algerian adult population where the vaccination program with BCG is in place since 1969 and where the WHO recommendations regardind the DOTS (directly-observed treatment, short course) strategy are in application. We consider a theoritical analysis and propose calibrations on Algerian data.

Keywords: Basic reproduction number, Dynamics, Epidemiological models, Tuberculosis.

Mathematical modeling of the regulatory network of mitochondrial apoptosis

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ABSTRACT

One of the key questions in systems biology is how the biological behavior of cells emerges out of the organization of individual molecules into functional networks. Mathematical modeling provides a unique chance for dynamic understandings of the network essences beyond various cellular transactions, such as adaptation, cell cycle, programmed cell death (apoptosis), and so on. In this paper, we try to perform an experimental observation-based computer simulation of the regulatory network of mitochondrial apoptosis, which have been extensively, yet far from completely studied recent years. By presenting a mechanistic mathematical model according to our latest understanding of this network, we were able to get dynamical characteristics of various apoptosis-related proteins, including: cytochrome c release, caspase activation, on the cell response to different apoptotic stimuli. Besides, through parameter analysis, we examined the role of Bcl-2 family proteins and a variety of natural inhibitors of apoptosis in controlling the downstream events of apoptosis. Furthermore, the effects of several amplified loops in the network are proposed to enhance the effect of caspase activation and make the process of apoptosis switch-like. Together the results of our simulations are consistent with available experimental evidences and could complement those wet-lab approaches to yield insight into the complex regulatory mechanisms of mitochondrial apoptosis.

Keywords: mathematical model, apoptosis, mitochondria, Bcl-2, IAP, cytochrome c, caspase

BISTABILITY IN AUTOCATALYTIC CHEMICAL REACTIONS

JUNPING SHI

We consider a parabolic system that models an isothermal autocatalytic chemical reaction. In one case we show that bistability exists for the system so that a threshold manifold separates the basins of attraction of two stable equilibria; and in another situation, we show that a "hair-trigger" effect occurs: if the initial value is below the steady state, then the solution of the system converges to a rest state of the system as time goes to infinity and so extinction occurs; if the initial value is above the steady state, then a wave front is developed and so we have the spread of "flame". The talk reports recent joint work with Xuefeng Wang of Tulane University, Yuwen Wang and Yuhua Zhao of Harbin Normal University, and Jifa Jiang of Tongji University.

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Key words and phrases. autocatalytic chemical reaction, asymptotic autonomous system, bistability.

SI MODELS WITH STAGE-STRUCTURE FOR PEST MANAGEMENT

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Abstract In this paper, two *SI* epidemic models with stage structure are proposed and investigated. In the first model, continuous biological control is taken, and we get the result that the susceptible pest eradication equilibrium E_0 is globally asymptotically stable, provided that $R_0 \leq 1$, or $R_0 > 1$ and $p > p_0$. In the second model, we get the result that the susceptible pest-eradication periodic solution $(0, 0, \widetilde{I(t)})$ is globally asymptotically stable, if $R_0 \leq 1$, or $R_0 > 1$ and $p > (e^{a\tau} - 1)\frac{b}{\beta}$; and the system is permanent, provided $R_0 > 1$ and $0 < p < \frac{b(1-e^{-a\tau})}{\beta}$. We think all the results will be helpful in pest management.

KEY WORDS: Stage structure; Biological control; Impulsive; Pest–eradication equilibrium; Pest-eradication periodic solution

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ABILITY OF CROSS-REACTIVE IMMUNE RESPONSE AND VIRUS ELIMINATION

TAKAHIKO SHIMIZU, YASUHIRO TAKEUCHI, AND SHINJI NAKAOKA

RNA virus has the low replication accuracy of reverse transcription, and escape from immune response via mutation. On the other hand, immune cells oppose against virus diversity with many repertories of antigenic recepters. In general, virus epitope stimulates one specific immune response. But not all immune responses are strain specific. There is a cross-reactive immune response which can recognize several virus epitopes.

We consider a mutation model with a cross-reactive immune response, and give the effective range of cross-reactive immune response against virus diversity.

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Key words and phrases. Virus mutation, Cross-reactive immune response.

A STAGE-STRUCTURED PREDATOR-PREY SYSTEM WITH MODIFIED LESLIE-GOWER AND HOLLING TYPE II SCHEMES

XINYU SONG AND MIN YU

In this paper, a stage-structured predator-prey system with impulsive harvesting on predators, and based on a modified version of Holling type-II scheme is investigated. Some sufficient conditions which guarantee the global asymptotical stability of prey-extinction periodic solution and the permanence of system are obtained. Finally, some discussion about this system are given.

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Key words and phrases. Prey-predator model; Stage-structure; Impulsive effect; Permanence.

Infectious Disease Forecasting Using Adaptive Neuro-Fuzzy Inference System

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Abstract: The occurrence of infectious diseases usually have a close connection with natural factors, say air temperature, air press, average precipitation, amount of evaporation, and etc. Due to all kinds of complicated interaction relations existing in among each factor, it therefore is very difficult to establish the accurate mathematic forecasting model of the infectious diseases using the conventional methods, such statistic method, experimental method, and observational method. On the other hand, as artificial neural networks (ANN) possess the complicated nonlinear mapping ability, it may be applied to perform the nonlinear system forecasting. However, ANN can't dispose the indeterminate, incomplete, and ill data problems, which limits its farther applications. To resolve this problem and change the situation, an adaptive neuro-fuzzy inference system (ANFIS) is proposed for infectious diseases forecasting in this paper. The method can automatically trace the changes of the input information characteristics, and compensate for the flaws of the ANN in dealing with fuzzy information. Through the research on the incidence rates of the typhoid and paratyphoid, the results indicate that the proposed method has higher identification rate, and is better than one of Bayesian discrimination analysis. ANFIS has stronger generalized ability and reasoning technique, it therefore has a broadly applied prosperity.

Keywords: Infectious disease; forecasting; ANFIS; Bayesian discrimination analysis

AN IMMUNE MATHEMATICAL MODEL OF ANTI-HBV INFECTION TREATMENT

YONGMEI SU AND LEQUAN MIN

The basic model of virus dynamics is widely used in the studies of virus infection dynamics. This model describes the virus dynamics, which the hosts do not have immune responds. Anti-virus therapy is aim to active the hosts' immune systems and interdict the copies of virus. Based on the basic model, this paper develops and explores a mathematical model consisting of four differential equations. The paper addresses the immune system's role in combating virus, interprets the mechanism of anti- virus treatment, and predicts the long term curative effects. This model has four equilibrium points Q_1, Q_2, Q_3 and Q_4 . Q_1 represents the host's complete recovery but without immune cells. Q_2 stands for the host's persistent infection no immune responds. Q_3 represents the host's complete recovery with immune responds. Q_4 stands for the host's persistent infection with immune responds. The stability conditions of the equilibrium points are given. An example of anti-hepatitis virus infection hepatitis treatment illustrates our theoretical model to be efficient in practical applications.

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Key words and phrases. immune, mathematical model, virus dynamics, hepatitis B.

PULSE CONTROL IN THE CHEMOSTAT MODEL WITH TOXIN

MINGJING SUN AND LANSUN CHEN

Abstract: Pulsed mathematical models of the effect of inhibitors on microbial competition are surveyed. The inhibitors are created internally as an anti-competitor toxin. We obtain an exact periodic solution with positive concentrations of substrate and toxin-producing microorganism. To analysis stability of this solution get an invasion threshold. We obtain the coexist of substrate, toxin-sensitive microorganism and toxin-productive microorganism. The theoretical results are verified by MATLAB computations.

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Analysis of two competitors and an external inhibitor in a pulsed bio-reactor model

Mingjing Sun Lansun Chen

Abstract: Mathematical models for a bio-reactor with two competitors, inhibitor and pulsed substrate are surveyed. We obtain an exact periodic solution by difference equation. Analysis for this solution produces a stable area, where only one competitor can survive in vessels . This is very important for our life. Meanwhile we also talk about complicated phenomena and simulate these graphs with Matlab.

AVIAN-HUMAN INFLUENZA EPIDEMIC MODEL –THE EXTERMINATION OF INFECTED BIRDS IS DANGEROUS–

YASUHIRO TAKEUCHI, SHINGO IWAMI AND XIANNING LIU

A mathematical model is proposed to interpret the spread of avian in uenza from the bird world to the human world. Our mathematical model warns that two types of the outbreak of avian in uenza may occur if the humans do not prevent the spread of avian in uenza. Moreover it suggests that we can not feel relieved although the total infected humans are kept at low level. In order to prevent spread of avian in uenza in the human world, we must take the measures not only for the birds infected with avian in uenza to exterminate but also for the humans infected with mutant avian in uenza to quarantine when mutant avian in uenza has already occurred. In particular, the latter measure is shown to be important to stop the second pandemic of avian in uenza.

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Key words and phrases. SIR model; SI model; Endemic; Pandemic; Avian in-uenza; Mutation .

MODELING CANCER RADIOVIROTHERAPY

YOUSHAN TAO

This talk deals with a procedure for cancer radiovirotherapy which requires not only injection of replication-competent viruses but also administration of radioiodide. The viruses infect tumor cells, replicate inside them and eventually cause their death. As infected cells die, the viruses inside them are released and then proceed to infect adjacent tumor cells. Radioiodide is in a continuous state of flux between the tumor and the remaining part. Iodide undergoes beta particle decay and the emitted beta particles have a significant effect on tumor cells. The combination of virotherapy with radiotherapy has been recently shown to be significantly more effective than treatment with virotherapy alone. Cancer radiovirotherapy can be described by a free boundary problem for a nonlinear system of partial differential equations, where the free boundary is the surface of a tumor. Global existence and uniqueness of solutions to this free boundary problem is proved, and a *new* explicit parameter condition corresponding to success of therapy is also found. Furthermore, numerical simulations are given to show that there is an optimal timing for radio-iodine administration, and that there is an optimal dose for the radioactive iodide.

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Key words and phrases. Tumors, virus, radioiodide, free boundary problems.

INSTABILITY INDUCED BY CROSS-DIFFUSION IN REACTION-DIFFUSION SYSTEMS

CANRONG TIAN AND ZHIGUI LIN

Our motivation is based on that forward diffusion in a single reaction-diffusion equation is a smoothing effect so that the solution become smooth and eventually converges to a constant equilibrium state for any initial data. However, for systems the combined effect of diffusion and reaction can become completely different and can result in destabilizing the constant equilibrium. **Previous work** list here. In 1952, Turing in his pioneering work stated that in a parabolic system modeling the interaction of two substances, different diffusion rates could lead to nonhomogeneous distributions of the reactants. From then on, diffusion driven instability, which generate spatial pattern in an ecological situation, has been emphasized in Biology and Mathematics. Many works have studied the spatial pattern in various important ecosystems, such as lakes, coral reef, woodlands, deserts and oceans. **The Basic Problem That We Studied** is

$$\begin{cases} \frac{\partial u_1}{\partial t} - \Delta(w_1(u_1,u_2)) = f_1(u_1,u_2), \\ \frac{\partial u_2}{\partial t} - \Delta(w_2(u_1,u_2)) = f_2(u_1,u_2), \end{cases} \tag{1}$$

Our aim is studying the instability of the uniform equilibrium of (1) as well as discussing the impact of cross-diffusion and domain on spatial pattern formation. **Our Results** in unbounded domain large cross-diffusion can induce Turing instability, in bounded domain large cross-diffusion and large domain size play roles in spatial pattern. In a competitive Volterra-Lotka system we investigate our results coincide with the statement the heterogeneity of the environment and the nonlinear dispersive movements give rise to the spatial segregation by Shigesada.

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PRINCIPAL EIGENVALUES OF NEUMANN EIGENVALUE PROBLEMS WITH INDEFINITE WEIGHTS

KENICHIRO UMEZU

In this talk we consider the following linear elliptic eigenvalue problem with an indefinite weight function and Neumann boundary condition:

$$\begin{cases} -\Delta\phi = \lambda g(x)\phi & \text{in } \Omega, \\ \dfrac{\partial\phi}{\partial \boldsymbol{n}} = 0 & \text{on } \partial\Omega. \end{cases}$$

Here Ω is a bounded smooth domain in $\mathbb{R}^N$, $N \geq 1$, and $\Delta = \sum_{j=1}^{N} \partial^2/\partial x_j^2$ is the usual Laplacian, λ is a positive eigenvalue parameter, $g \in L^\infty(\Omega)$, g is positive on a set of positive measure and $\int_\Omega g\,dx < 0$, and $\boldsymbol{n}$ is the unit outer normal to the boundary $\partial\Omega$.

The purpose of this talk is to discuss necessary and sufficient conditions of a sequence $\{g_j\}$ of the weight functions for the unique principal eigenvalue $\lambda_1(g_j)$ to have the blowing-up property

$$\lim_{j\to\infty} \lambda_1(g_j) = \infty.$$

This is based on the variational characterization of the unique positive principal eigenvalue. In the case when $\phi|_{\partial\Omega} = 0$, Cantrell and Cosner (*Proc. Roy. Soc. Edinburgh* **112A** (1989), 293-318) gave a necessary and sufficient condition for the blowing-up property as follows:

$$\limsup_{j\to\infty} \int_\Omega g_j\psi\,dx \leq 0, \quad \forall\psi \in L^1(\Omega) \text{ with } \psi \geq 0 \text{ a.e. in } \Omega.$$

In the Neumann case, a counterexample of $\{g_j\}$ is constructed, which shows that this condition is no longer sufficient for the blowing-up property.

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Key words and phrases. Principal eigenvalue, Blowing-up property, Neumann boundary condition, Indefinite weight, Population dynamics.

AN SEIS EPIDEMIC MODEL WITH TRANSPORT-RELATED INFECTION

WAN HUI AND JINGAN CUI

In this paper, an SEIS epidemic model is proposed to study the effect of transport-related infection on the spread and control of infectious disease. New result implies that travelling of the exposed (means exposed but not yet infectious) individuals can bring disease from one region to other regions even if the infectious individuals are inhibited from travelling among regions. It is shown that transportation among regions will change the disease dynamics and break infection out even if infectious diseases will go to extinction in each isolated region without transport-related infection. In addition, our analysis shows that transport-related infection intensifies the disease spread if infectious diseases break out to cause an endemic situation in each region, in the sense of that both the absolute and relative size of patients increase. This suggests that it is very essential to strengthen restrictions of passengers once we know infectious diseases appeared.

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Key words and phrases. SEIS epidemic model; Transport-related infection; Basic reproduction number; Stability.

MODELING DISEASES WITH LATENCY AND RELAPSE

P. VAN DEN DRIESSCHE, LIN WANG, AND XINGFU ZOU

A general mathematical model for a disease with an exposed (latent) period and relapse is proposed. Such a model is appropriate for tuberculosis, including bovine tuberculosis in cattle and wildlife, and for herpes. For this model with a general probability of remaining in the exposed class, the basic reproduction number $\mathcal{R}_0$ is identified and its threshold property is discussed. In particular, the disease-free equilibrium is proved to be globally asymptotically stable if $\mathcal{R}_0 < 1$. If the probability of remaining in the exposed class is assumed to be negatively exponentially distributed, then $\mathcal{R}_0 = 1$ is a sharp threshold between disease extinction and endemic disease. A delay differential equation system is obtained if the probability function is assumed to be a step-function. For this system, the endemic equilibrium is locally asymptotically stable if $\mathcal{R}_0 > 1$, and the disease is shown to be uniformly persistent with the infective population size either approaching or oscillating about the endemic level. Numerical simulations (for parameters appropriate for bovine tuberculosis in cattle) with $\mathcal{R}_0 > 1$ indicate that solutions tend to this endemic state.

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Key words and phrases. bovine tuberculosis, delay differential equation, disease-free equilibrium, endemic equilibrium.

OPTIMIZATION OF BIODEGRADATION IN SEQUENCING BATCH REACTOR OF TANNERY WASTEWATER USING RESPONSE SURFACE METHODOLOGY

QI WANG AND QIANG KE

Abstract: Response surface methodology (RSM) based on Box-Behnken statistical design was applied to optimize the biodegradation process conditions in sequencing batch reactor (SBR) on the removal of organic pollutants from tannery wastewater using chemical oxygen demand (COD) removal as the dependent variables and the initial concentration of organic matter, aeration time and pH as the independent variables. The analysis of variance (ANOVA) of the quadratic model demonstrates that the model was highly significant. Using the RSM, the optimal values of pH, aeration time, initial concentration were 7.41, 6.5 h and 1032.3mg/L, respectively. It was proved that RSM combined with SBR could be an effective way for optimizing the biodegradation process in tannery wastewater.

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Key words and phrases. Response surface methodology; Box-Behnken statistical design; Tannery wastewater; Sequencing batch reactor; Biodegradation.

ON OPTIMAL HARVESTING POLICY OF A DELAYED PREDATOR-PREY SYSTEM WITH AGE-STRUCTURE

FENGYAN WANG AND SHUWEN ZHANG

Based on the classical delayed single species stage-structured model and Lotka-Volterra predator-prey model, we introduce and study a delay predator-prey system with two life stages, immature and mature, with a mature population of harvesting. The delays are constant maturation time delays of prey and predator species. It is shown that there exists a unique positive equilibrium which is globally asymptotically stable or the predator dies out by using an iterative scheme. We also obtain the optimal harvesting policy and the threshold of sustainable. The effect of maturation delay of predator on the populations at equilibria is considered.

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Key words and phrases. Keywords: Optimal harvesting policy; Stage structure; Predator-prey system; Equilibrium.

DISPERSAL PERMANENCE OF PERIODIC PREDATOR-PREY WITH IVLEV-TYPE FUNCTIONAL RESPONSE AND IMPULSIVE EFFECTS

HAILING WANG AND WEIMING WANG

In this paper, we study the permanence of a periodic Ivlev-type predator-prey system where the prey disperses in patchy environment with two patches. We assume the Ivlev-type functional response within-patch dynamics and provide a sufficient condition to guarantee the predator and prey species to be permanent. Furthermore, we give numerical analysis to confirm our theoretical results. It will be useful to ecosystem control.

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Key words and phrases. Dynamic system; Predator-prey model; Ivlev-type functional response; Impulsive perturbation; Coincidence degree; Periodic solution; Numerical analysis.

ENHANCED MODELING OF THE GLUCOSE-INSULIN SYSTEM AND ITS APPLICATIONS IN INSULIN THERAPIES

HAIYAN WANG, JIAXU LI, AND YANG KUANG

Several mathematical models have been proposed to model the glucose-insulin system and these models assume that insulin degradation is proportional to insulin production. In this talk, we will introduce a new model for the glucose-insulin regulatory system by revisiting insulin degradation. We will provide mathematical analysis of the new model. Some applications in insulin therapies will be discussed. Numerical simulations show that the proposed model is more realistic.

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Key words and phrases. Diabetes, glucose-insulin regulator system, insulin therapy, time delay, periodic solution, stability.

A Three-dimensional Numerical Analysis of Screwed Miniplates Stress in Mandibular Symphysis Reduction

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Key words and phrases. 3-D finite element analysis, Von Misses stress, mandibular symphysis fracture, rigid internal fixation

ABSTRACT. Rigid internal fixation for the maxillofacial fractures has made significant advances due to improved understanding of biomechanical principles. This study was to establish a 3-demensional finite-element (FE) mandibular symphysis fractured model and investigate the occlusal reaction at the teeth after different miniplate-screw fixation techniques. A dentate, adult human cadaver imagined by CT was evaluated. The data were carried out in the pre-processor of the Ansys 7.0 program. The different structures in the FE model of mandible were assigned different material characteristics. The mandibular symphysis fracture was simulated. The miniplate and screw model (4-hole, and noncortical) were set by Pro/E program. The model was used to simulate three static biting tasks: intercuspal position (ICP); incical clenching (INC); and right unilateral molar clenching (MOL). Groups of parallel vectors simulated nine pairs of masticatory muscles assumed to be directly attached to bone. The Von Misses stresses in the miniplate-screw hardware under different fixation techniques (one or two screwed miniplates) were compared. The predictive accuracy 3-D FEA model was built and the finial model consisted of more than 200,000 elements. The model was simulated the rigid internal fixation for the mandibular symphysis fracture under the 3 occlusal tasks. The maximum Von Misses stress in the miniplates were different under different biting task and that in one miniplates was more concentrated than two miniplates fixation method. The maximum stress of one miniplate was 3838 MPa under the MOL biting which beyond the yield limit of Ti. With the two miniplate fixation, the stress in the upper one(ICP:654,INC:773,MOL:6218) was lager than that in the lower one(ICP:424, INC:271,MOL:1073).The screwed miniplate reaction stresses of the symphysis fractured mandible were not too concentrated under the INC and ICP condition both in two fixation techniques, while under the MOL condition, it was not. FE model under the functional condition was established in this study and it was useful to evaluate the biomechanical behavior of the fractured mandible in the screwed miniplates fixation. The 3-D finite element analysis was used to evaluate the stress in the fixation hardware after the rigid internal fixation of the mandibular fractures. The model was an accuracy and functional model, and the fixational hardware model was also establish by Pro/E instead of simple boundary.

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A CLASS OF NONLINEAR MULTISTAGE DYNAMICAL SYSTEM AND ITS OPTIMAL CONTROL

HUIYUAN WANG, ENMIN FENG, AND ZHILONG XIU

In this paper we study a nonlinear multistage dynamical system as well as its optimal control. Specifically, based on the batch fermentation including three different phases of the bio-dissimilation of glycerol to 1,3-Propanediol by *Klebsiella Pneumonicae*, the nonlinear multistage dynamical system is proposed. Then we discuss several properties of this nonlinear system. In order to optimize the initial state such that the concentration of 1,3-Propanediol at terminal time is as large as possible, an optimal control model is established. We investigate existence of the local maximizer. Furthermore, by using the infinite-dimensional optimization principle, the necessary condition for the optimal control problem is obtained. Finally, employing some properties of the feasible region, the infinite-dimensional constraints can be transformed into finite-dimensional constraints. The transformation is significant for constructing the optimization algorithm of the optimal control problem.

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Key words and phrases. Bio-dissimilation, nonlinear multistage dynamical system, batch fermentation, optimal control.

AN APPROACH TO ECOLOGICAL FIELD OF ANNUAL WEED POPULATION BY CA MODELING

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Key Words: Ecological Field, Weed population, CA Modeling

Abstract Ecological field theory (EFT) quantifies the effect of an individual on its neighbors using geometric zones of influence that surround individual plants (Wu et al., 1985; Sharpe et al., 1986; Walker et al., 1989; Mou et al., 1993, Li, et al. 2000). In ecological field theory, two concepts, ecological interference from Harper (1977) and potential from field theory in physics are combined to form a new concept, ecological interference potential or ecological field (Wu, et al. 1985, p.216, p217, p.241). In the theory, "Ecological Field" implies a measure of interference that a newly germinated seedling must overcome to establish itself and subsequently grow at a given site within the influences of all neighboring plants (Wu, et al. 1985, p.217). Accordingly, the theory is only applicable to individuals. In this article, we have extended the theory of "Ecological Field" from individual to population, which was defined as ecological potential of weed population resisting interference from external. We have built a cellular automata (CA) model of annual weed population dispersal in a controllable system (Wang et al., 2003), and while simulating, the "Ecological Field" of annual weed population have found out. Consequently we explored the intrinsic causes of weed forming patches and control mechanism by simulating. Patch distributions being often observed in field are the most essential distribution patterns of organisms. Numerous studies have demonstrated that spatial characteristics of a landscape, such as patch size, patch shape, patch density, and patch arrangement, are the basic features controlling ecological processes within a landscape (Forman and Godron, 1986; Franklin and Forman, 1987; Milne, 1988; Ripple et al. 1991). Thus studies on patch distribution are essential to help us to insight into the mechanism of population extinction, spread and control in conservation ecology, restore ecology, weed ecology and landscape management (Grasman and HilleRisLambers 1997; Holyoak, 2000; Hiebeler, 2000; Kindvall and Petersson, 2000; Keymer, et al. 2000). For instance, many weed species characteristically patchiness in their distribution within arable field (Howard, et al. 1991), which is of interest to weed management because it offers the opportunity to control weed patches only (Wallinga and Kropff, 1997) to reduce usage of herbicide and manage economically agricultural production. Most studies attribute the main causes of forming patch distributions to heterogeneous environment (Hiebeler, 2000; Holyoak, 2000; Lefkovitch and Fahrig 1985) and seldom studies involved intrinsic characteristics of organism population aggregation. Having simulated the CA model describing annual weed spread, we found out the intensity of "Ecological Field" depends on patch size, plant density in the patch and characteristics of plant seed dispersal. However, the intensity of its "Ecological Field" will not change with increase of patch size after patch size exceeds a fix value. Also we found out that "Ecological Field" intensity of several patches combining together, "Ecological Field" intensities of which are small, enhance markedly so that the plants in group of the patches increase resistance against interference. This may demonstrate theoretically the fact that the species with island distribution have more risk to extinct. Therefore we infer that "Ecological Field" is one of causes that plant population distributes patchily. Based on the results, we may have hypotheses: 1.there exists a patch with minimum size, in which plants of a species grow aggregately, so that the intensity of its "Ecological Field" weakens when its size decreases, while that does not enhance with the increase of its size; 2.there exists a law of mean density in (annual) weed control, that is when a isolated patch of weed is controlled, control intensity (dosage of herbicide) may be calculated based on weed mean density in the patch.

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An Epileptic Prediction Method Based on Improved Kolmogorov Complexity

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Abstract

Epilepsy is the most common neurological disorder in the world, second only to stroke. There are nearly 60 million people who suffer from recurrent epileptic seizures. Almost 75% of them can be controlled by medicines or cured by surgical intervention. However, the remaining one-quarter of the patients suffers from refractory epilepsy, with no available therapy to their seizures.

In this paper, we introduce an epilepsy seizure prediction algorithm from scalp EEG based on improved Kolmogorov complexity that identifies the change of brain activities from interictal state to preictal state. A novel binary symbolization method is presented to extract all the epileptic activities in scalp EEG, including spikes with different amplitude and slow waves. After that, Kolmogorov complexities curve on focal and remote region electrodes are calculated with a sliding window of 40 seconds and moving step of 3 seconds. Results show that only Kolmogorov complexity of electrodes on focal region decreases when seizure is approaching. Then the following criterion on seizure prediction is decided: A warning alarm will be triggered when the average Kolmogorov complexity on focal region in recent 1 minute is lower than a preset threshold.

Then, the proposed seizure prediction algorithm is validated by clinical scalp EEG data collected from 3 patients of Zhejiang Provincial People's Hospital, China, including 5 EEG segments with total duration of 538 minutes. Data acquisition system is Phoenix Unique Ambulatory EEG of EMS Handelsges.mbH company, Austria. Exploring cup electrodes were fixed according to the International 10－20 System, and the reference electrodes are located on the ipsilateral ear electrode. Video recordings are acquired synchronously with EEG, by which an experienced physician confirms the clinical seizure onset. Sensitivity, specificity and mean prediction time are utilized in algorithm evaluation. Especially, A more reliable method to assess the specificity proposed by Mormann in 2006 is employed. It suggests the portion of time from the interictal period during which a patient is not in the state of falsely waiting for a seizure. The analysis results indicate that the average prediction time of the proposed method is 4.2 minutes, the mean sensitivity is 76.1% and specificity is 27.0%.

Keywords: Epilepsy, Seizure prediction, Improved Kolmogorov complexity,

PROPAGATION OF HBV WITH SPATIAL DEPENDENCE

KAIFA WANG AND WENDI WANG

A mathematical model is proposed to simulate the hepatitis B virus (HBV) infection with spatial dependence. The existence of traveling waves is established via the geometric singular perturbation method. Numerical simulations show that the model admits non-monotone traveling profiles. Influences of various parameters on the minimum wave speed are also discussed.

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Key words and phrases. HBV; infection; diffusion; waves; perturbation.

Optimal harvesting of two competing species with age dependence and diffusion

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Abstract. In this paper, we consider an optimal harvesting problem for a system consisting of two competing populations with age structure and diffusion. By using Mazur's theorem, we demonstrate existence of solutions of the optimal control problem, and by conception of normal cone we also obtain the first order necessary conditions of optimality for the problem. Our results extend some known criteria.

Key words: Optimal control, age-dependent, diffusion, system of partial differential equations, Maximum Principle of Pontryagin.

Effect of impulse on evolutionary game dynamics[1]

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Abstract

Evolutionary game dynamics has an essential concept ESS, and the ESS approach is both simple and powerful in the study of evolutionary dynamics. In this paper, we study the evolutionary dynamics with constant periodic impulsive effect making use of impulsive differential equation. The result show that solution of the simple replicator equation may be periodic and the traditionary concept of ESS lose the property of uninvadability, that is，mutant strategies can invade. These studies suggest a mechanism that an ESS may be inaccessible.

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abstract

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Asymptotic malaria infection is common in malaria-risk area. Considering two different immune responses (innate immunity and adaptive immunity), mathematical models are formulated to study the impact of treating individuals with asymptotic malaria infection. Basic reproductive numbers are derived and stability analysis is conducted at the disease-free equilibrium (DFE). Stability of endemic equilibrium is studied by numeric simulations. We show that treating as low as 3% individuals with asymptotic malaria infection will reduce the prevalence of infection dramatically.

BIFURCATION ANALYSIS OF A PREDATOR-PREY SYSTEM WITH TYPE II FUNCTIONAL RESPONSE AND PREDATORS USING HAWK-DOVE TACTICS

XIAOLI WANG AND WENDI WANG

In this paper, we study an autonomous predator-prey system in which individuals in the predator can use two behavioral tactics to dispute a prey when they encounter, the classical hawk and dove tactics. Type II functional response is considered in this work. The aim of this work is to study the effects of individual predator behavior on the dynamics of the predator-prey system with type II functional response. It is proved that the predator-prey system may admit a sequence of bifurcations including saddle-node bifurcation, Hopf bifurcation and homoclinic bifurcation.

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Key words and phrases. Predator-prey model; Pay-off matrix; Aggregation method; Saddle-node bifurcation; Hopf bifurcation; Bogdanov-Takens bifurcation.

A STAGE-STRUCTURED DELAYED PREDATOR-PREY SYSTEM WITH FUNCTIONAL RESPONSE

YAN WANG AND JIANHONG WU

In this paper, A nonautonomous stage-structured predator-prey system with functional response and time delay is studied. Qualitative analysis of the model such as boundedness of solution, permanence and periodic solutions is provided, and some sufficient conditions for the uniform permanence of the system is derived. The global attractivity of a positive periodic solution is obtained using a appropriate Lyapunov functional coupled with the Razumikhin's technique is established, and some numerical simulations are presented to illustrate the main results.

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1991 *Mathematics Subject Classification.* The AMS Subject Classification.
Key words and phrases. Functional response;Permanence; Time delay; Periodic solution;Global attractivity.

GLOBAL STABILITY AND HOPF BIFURCATION ON A PREDATOR-PREY SYSTEM WITH DIFFUSION AND TWO DELAYS

YUQUAN WANG

Abstract: In this paper, a predator-prey system with diffusion and two delays is considered. The system is composed of two patches, and the predator functional response is Holling type-II function. It is shown that the system is persistent under some appropriate conditions, and the sufficient conditions for both local and global stability of a positive equilibrium are obtained by constructing a suitable Lyapunov function. When the time delays are regarded as parameters, the Hopf bifurcation problem is discussed by analyzing the associated characteristic equation. The numerical results of simulating this system are presented at justifying our main conclusions.

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Key words and phrases. Holling II functional response, Delay, Persistence , Stability, Hopf bifurcation.

Epidemiological Dynamics of Current Co-circulation of Two Influenza A Subtypes H1N1 and H3N2 in the United States

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Keywords: influenza subtype, co-circulation, predator-prey model, epidemiological dynamics, evolutionary dynamics, H1N1 and H3N2.

Abstract:

Although new influenza antigenic variants by drift ceaselessly emerge, two influenza A subtypes H1N1 (H1) and H3N2 (H3) persist and co-circulate in human population, since H1 was reintroduced in humans in 1977. However, it is still enigmatic of the reason for co-circulation (i.e. the characteristic pattern observed during 1998-2006 in the United States) especially, how it differs from co-circulation of influenza types A and B. We herein resorted to an ecological model and investigated the epidemiological dynamics of the co-circulation. We found that due to the heterosubtypic cross-protection provided by short-lived T cells, the co-circulation of influenza subtypes (H1 and H3) is distinguished from co-circulation of types (A and B) in humans. During co-circulation, the dominating subtype advantageously produces mutants by antigenic drift, and the mutants may greatly change the succeeding co-circulation pattern.

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QUALITATIVE ANALYSIS FOR A RATIO-DEPENDENT PREDATOR-PREY MODEL WITH STAGE STRUCTURE AND DIFFUSION

WANG ZHIGUO AND WU JIANHUA

The present essay is purported to study a reaction diffusion system arising from a ratio-dependent predator-prey model with stage structure. The global and locally asymptotic stability of the unique positive constant equilibrium is obtained under suitable conditions, existence and non-existence results of non-trivial solution are derived.

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Key words and phrases. Ratio-dependent, Prey-predator model, Diffusion, Stage-structure.

A CHRONIC VIRAL INFECTION MODEL WITH IMMUNE IMPAIRMENT

ZHIPING WANG AND XIANNING LIU

A chronic viral infection model with cell-mediated immunity and immune impairment is proposed and studied, under the assumption that the presence of the antigen can both stimulate and impair immunity. It is shown that the virus persists in the host if the basic reproductive ratio of the virus is greater than one. The immune cells persist when there is only one positive equilibrium. The system can exhibit two positive equilibria if the basic reproductive ratio of the virus is above a threshold. This allows a bistable behavior, and the immune cells persist or die out, i.e., infection will result in disease or immune control outcome, depending on the initial conditions. By theoretical analysis and numerical simulations, we show that therapy could shift the patient from a disease progression to an immune control outcome, despite that the therapy is not necessarily lifelong. This would allow the immune response to control the virus in the long term even in the absence of continued therapy.

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Key words and phrases. Virus dynamics; Immune impairment; Immune control; Stability; Permanence.

Research of Financial Stability with Ecology Stability Theory

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Abstract: After Asian crisis the demonstrative research on evaluating the stability of financial system has been made great progress, but its theoretical research has still lagged. This paper uses ecology stability method to study financial stability. Firstly it compares the difference between financial stability and ecology stability. It then transfers ecology stability to financial system and establishes financial population model, defining ecology finance stability of financial population, demonstrating the stability of financial population model and stochastic model. Finally, this article analyzes the stability of tier structure of financial population. We hope this paper could help the scholars who are interested in financial stability.

Key words: financial system; financial stability; ecology stability; financial population

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MATHEMATICAL MODELLING OF RIVER-BORNE SPREAD OF JAPANESE KNOTWEED

JOHN WARD AND JAMES SMITH

Japanese Knotweed (Fallopia japonica) is a highly invasive, rhizomal plant, native to eastern Asia, that has become a major problem in Europe, USA, Canada and New Zealand since their artificial introduction. These plants aggressively displace native species, taking over habitats and reducing biodiversity. Furthermore, their rhizomes (underground stems) are capable of damaging buildings and roads. Management of these plants is made very difficult due to the capability of very small rhizomal fragments to grow and quickly regenerate a knotweed patch. This makes eradication difficult, as the entire rhizome network needs to be removed. Moreover, fragments are easily transported by rivers and canals, which greatly enhances their rate of spread along banks and into new areas.

In this talk, we start by discussing briefly the results of a model of rhizomal spread using a correlated random walks, which motivates the use of Fisher's equation to model events over large time and space scales. These ideas are extended to model the effect river flow on enhancing knotweed expansion both up- and down-stream. By a suitable rescaling, the model reduces to a system consisting of coupled PDEs governing land knotweed density and river fragment density. Travelling wave solutions are investigated in the 1-D case and expansion speeds are determined in terms of the model's parameters with interesting results. Finally, 2-D simulations will be presented to illustrate the impact of river-borne spread.

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1991 *Mathematics Subject Classification.* 92D40.
Key words and phrases. Japanese Knotweed, dispersal, rivers, travelling wave analysis.

The Influence of Population Movement on the Transmission Effect of Infectious Disease

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Abstract: An SIS model for an infectious disease in population movement is formulated and analyzed. The model is used to assess the impact of observed difference in travel on the spread of the epidemic. The disease free equilibrium and endemic equilibrium are also discussed.
Under several proper assumptions, the result shows the global stability and the multiplier effect on the epidemic of the model with disease transmission.

Key words: Disease transmission; Basic reproduction number; Global stability; Population movement

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ASYMPTOTIC PATTERNS OF A STRUCTURED POPULATION DIFFUSIVE IN A 2-DIMENSIONAL STRIP

PEIXUAN WENG, DONG LIANG, AND JIANHONG WU

In this paper, we derive a population model for the growth of a single species on a 2-dimensional strip with Neumann and Robin boundary conditions. We show that the dynamics of the mature population is governed by a reaction-diffusion equation with delayed global interaction. Using theory of asymptotic speeds of spread and monotone traveling waves for monotone semiflows, we obtain the spreading speed c^*, the nonexistence of traveling waves with wave speed $0 < c < c^*$, and the existence of monotone traveling waves connecting the two equilibria for $c \geq c^*$.

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Key words and phrases. Structured population model, monotone semiflows, spreading speed, asymptotic patterns, traveling waves, 2-dimensional strip.

Modeling time delay and spatial spread in pandemic influenza

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We summarize some recent progress on modeling pandemic influenza and its applications to public health policy design to mitigate the disease burden. We shall focus on the issue that the antiviral treatment requires tracking the disease age carefully, as such a system of delay differential equations with both discrete and distributed delays seems to be most appropriate. Consideration of spatial spread may further complicate the investigation as it leads to a non-local diffusion problem with time lag. Other issues on drug resistance and the importance in protecting health care workers will also be addressed.

COMPLETE CONVERGENCE FOR WEIGHTED SUMS OF $\widetilde{\rho}$-MIXING RANDOM VARIABLE SEQUENCES

WU QUNYING AND JIANG YUANYING

In this paper, we study the weak convergence and complete convergence for $\widetilde{\rho}$-mixing random variable sequences. As a result, we extend the classical weak law of large numbers, and Baum and Katz complete convergence theorem etc. for independent random variable sequences to $\widetilde{\rho}$-mixing random variable sequences without necessarily adding any extra conditions..

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Key words and phrases. $\widetilde{\rho}$-mixing random variable sequence; weak law of large numbers; complete convergence.

INTRA-HOST MATHEMATICAL MODELS ON HOST-PATHOGEN INTERACTION AND TREATMENT

DONGMEI XIAO

The aim of this talk is to understand the pathogenesis of an infectious disease by mathematical modeling of host-pathogen interactions. We present basic principles on the interaction of the immune system in response to a class of pathogens that challenge humans. Then we give a mathematical model for host-pathogen interactions at the cellular level, and the other mathematical model for modeling disease progression and subsequent therapy. Some mathematical analysis and numerical simulations are given for two models.

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Key words and phrases. Mathematical model, host-pathogen interaction and treatment.

PAIR APPROXIMATIONS AND THE INCLUSION OF INDIRECT TRANSMISSION: THEORY AND APPLICATION TO BETWEEN FARM TRANSMISSION OF *SALMONELLA*

YANNI XIAO AND ROGER BOWERS

The spatial-temporal dynamics of farm animal diseases depend both on disease specific processes and the underlying contact network between farms. Indirect transmission via free-living bacteria in the environment is an important transmission route and contributes significantly to the dynamics. The pair-wise model has been developed to include both direct transmission and indirect transmission via free stages. The model is compared with stochastic simulations of epidemics on contact networks. The network framework is applied to the investigation of the epidemiological dynamics of between-herd transmission of *Salmonella* spp. The main results help to explain differences in observed epidemiological patterns and to identify possible causes for different strains of *Salmonella* developing so much variation in their infection dynamics in UK dairy herds. Numerical results show that shorter infectious period, more persistent immune response and more rapid removal of faeces result in a lower prevalence of infection and a greater tendency for (damped) oscillation. A possible control strategy is consequently suggested. Furthermore, the effect of network structure on long-term dynamics is examined.

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Key words and phrases. pair-wise model; indirect transmission; stochastic simulation; prevalence; Salmonella.

STABILITY AND BIFURCATION IN A PREDATOR-PREY MODEL WITH PREY DISPERSAL AND TIME DELAY

RUI XU AND ZHIEN MA

Dispersal is a ubiquitous phenomenon in the natural world. Its importance in understanding the ecological and evolutionary dynamics of populations was mirrored by the large number of mathematical models devoted to it in the scientific literature. Because of the ecological effects of human activities and industry, e.g., the location of manufacturing industries and pollution of the atmosphere, rivers, and soil, more and more habitats have been broken into patches and some of the patches have been polluted. In some of these patches, and sometimes even in every patch, species will become extinct without contributions from other patches, and hence the species live in a weak patchy environment. In this paper, a predator-prey model with prey dispersal and time delay due to the gestation of the predator is investigated. By analyzing the corresponding characteristic equation, the local stability of the positive equilibrium is discussed. The existence, direction and stability of Hopf bifurcations are also addressed. By using an iteration technique, sufficient conditions are derived for the global attractiveness of the positive equilibrium of the proposed model. Numerical simulations are carried out to illustrate the main results.

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Key words and phrases. Predator-prey model, dispersal, time delay, Hopf bifurcation, stability, permanence, extinction.

A SIQS Infctions Disease Model with Isolation

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ABSTRACT A SIQS infctions disease model with isoation is researched with using the stability theory of differential equation and infectious disease model theory. the thresholds value R_0 of equilibrium point are found in the disease model .At the same time, The disease-free equilibrium point is locally stable if $R_0 < 1$ and the endemic equilibrium point is locally stable if $R_0 > 1$. sufficient conditions are obtained of Endemic equilibrium point is globally stable by constructing Liapunov functions and gived from the angle of biology to explain.

KEY WORDS epidemic model； isolation；equilibrium point；threshold value

The tuberculosis model with saturating contact

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Abstract: In this paper,the tuberculosis model with saturating contact rate is studied. The basic reproduction number R_0 is proved to be a sharp threhold, which completely determines dynamics and outcome of disease.If $R_0<1$, the disease-free equilibriumis globaly stable and the disease always dies out.If $R_0>1$,there exists a unique endemic equilibrium and it is persistence.

A Parallel Signal Identification Algorithm based on Tiling Array data

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In this paper, we analyze the tiling array data of human chromosome 22 built by Affymetrix technology. These data contain a paired "mismatch" probe for each genomic tile probe. Here what we are interested is to detect transcription targets. Based on a great deal of literature research we use the Kampa algorithm which was developed for a large scale Affymetrix experiment. As for each probe, one Hodges-Lehman estimator, or 'pseudo-median' is calculated. Any probe having a Hodges-Lehman estimator above a threshold is considered 'positive ', or transcribed. Transcribed fragments, or 'transfrags' were then constructed from lists of positive probes by merging those that lie in close genomic proximity in length.

After we basically realized Kampa method, we also considered the possibility that tiling array data with different structures will be submitted, for example, tiling array experiment without mismatch probe. Meanwhile, the window size and other parameters can be decided according to different chips and different tiling paths. Moreover, the transcribed percent of a given chromosome region can be judged. We refined the program in order to supply a more flexible surface.

Following the generation of transfrag maps, regions of observed transcription were classified based on the overlap of base pairs in transfrags to elements in a collection of annotation classes. In the body of this paper, we will give some proportion about the transcription.

With the increase of tiling array dataset, serial program is too much time-consuming. So we proposed an MPI parallel design project. The basic idea is to cut the data set evenly into several parts. In the program, each process counts its own probe records with which it will run and executes afterwards. At last the main process gathers the results of all processes and finds out the transcribed probes according to their Hodges-Lehman estimator. From the speedup and efficiency we can find out that this design perfectly implements the parallel design with high parallel efficiency.

We'll wrap up serial program into a package and integrate the parallel software of Kampa to our project so that it could provide computing service to the bioinformatics researchers who need to handle the tiling array data.

GLOBAL STABILITY OF GOMPERTZ MODEL OF THREE COMPETING POPULATIONS

YUMEI YU, WENDI WANG, AND ZHENGYI LU

The model of three competitive populations with Gompertz growth is studied, according to the relation of the extent between the interspecific and the intro-specific competitions. The periodic solutions are ruled out by generalized Dulac criteria. On the basis of the analysis, we obtain conditions that ensure the asymptotic behavior of the model is simple. Meanwhile, the results that either the boundary equilibrium is globally asymptotically stable or the boundary equilibria are bistable are obtained via the irreducible and competitive system theory about the periodic orbits. With the help of the criteria of Hopf bifurcation without using eigenvalues, two classes of Hopf bifurcations are shown. Limit cycle, which may run from one class of Gompertz system to another class, has been found through MatCont. And a stable limit cycle, which derived from Hopf bifurcations and run from the system with half strong and half weak interspecies competitions, is observed through numerical simulations via MatCont in the Gompertz system of two weak interspecies competitions with the recurrent mark.

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Key words and phrases. Gompertz model; Competing populations; Periodic solutions; Global stability; Generalized Dulac criteria.

A Mathematical Model for Somite Segmentation

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Somites are periodical patterns arise from presomitic mesoderm (PSM). New somites form in the rostral PSM and new PSM cells are added to the caudal end. Now it is widely accepted that this periodical pattern is controlled by a clock and wavefront mechanism, identification of cycling genes have provided evidence for an intrinsic oscillatory mechanism in PSM cells. The expression of cycling genes appears as waves that sweep across the PSM from posterior to anterior at a certain time, shrinking its width while moving and come to rest in somewhere new somite is generated. Although the mechanism is largely unknown, experimental and gene-expression data strongly indicated that Notch pathway is the core of somite clock. Notch pathway not only drive the oscillation in individual cell, but also maintain the synchronized oscillation between cells.

We developed a three-component reaction diffusion system of one-activator-two-inhibitor type to simulate somite segmentation process based on the clock and wavefront mechanism. Introducing heterogeneity on kinetic parameter give rise to a periodical pulse solution which behaves as the gene expression waves in somite segmentation process. Bifurcation analysis on the model provides a great understanding of Notch pathway feedback loop and give us a hint to understand the biology phenomena.

DYNAMICAL ANALYSIS OF A STAGE-STRUCTURED PREDATOR-PREY SYSTEM WITH GENERAL RATIO-DEPENDENT FUNCTIONAL RESPONSE

YUAN YUAN AND XIAN-NING LIU

In this paper, we consider a ratio-dependent predator-prey system with stage structure for the prey. It is assumed that immature and mature individuals of prey population are divided by a fixed age and that predator individuals only prey on the immature prey individuals. Existence of equilibria is discussed and their local asymptotical stability is analyzed by linearization and system transforming since the system can not be linearized at the origin. It is shown that the system is uniformly persistent when the positive equilibrium exists. And the global asymptotical stability of boundary equilibrium, which implies the extinction of predator population, is studied by limit system theory and Dulac criterion.

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Key words and phrases. Stage structure; Uniform persistence; Predator-prey system; Global stability.

Dynamics in Three Cells with Multiple Time-delays

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Abstract

We consider systems of delay differential equations representing the models containing three cells with any time-delayed connections. Global stability, delay-independent and delay-dependent local stability are studied, the existence of local and global periodic solutions are investigated. We give the stability conditions respectively, and show that the local periodic solutions can be extended globally after certain critical values of delay.

A NONAUTONOMOUS DELAYED EPIDEMIC MODEL WITH STAGE-STRUCTURE AND PULSES FOR PEST MANAGEMENT STRATEGY

HONG ZHANG AND LANSUN CHEN

From a biological pest management standpoint, epidemic diseases models have become important tools in control of pest populations. This paper deals with a nonautonomous impulsive delay epidemic disease model with stage-structure and a general form of the incidence rate concerning pest control strategy, in which the pest population is subdivided into three subgroups: pest eggs, susceptible pests, infectious pests that do not attack crops. Using the discrete dynamical system determined by the stroboscopic map, we obtain the exact periodic susceptible pest- eradication solution of the system and observe that the susceptible pest-eradication periodic solution is globally attractive provided that the amount of infective pests released periodically is larger than some critical variable for all $t \geq 0$. When the amount of infective pests released is less than another critical variable for t large enough, the system is shown to be permanent, which implies that the trivial susceptible pest-eradication solution loses its attractivity. Our results indicate that besides the release amount of infective pests, the birth rate function, incidence rate, time delay and impulsive period can have great effects on the dynamics of our system.

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DECAY RATES FOR SOLUTIONS OF A CLASS BIOLOGICAL POPULATION EQUATION

QINGYING HU AND HONGWEI ZHANG

In this paper, we are concerned with the decay rates for the weak solution of the following biological population equation,

$$u_t = \Delta(|u|^{m-1}u) + f(u), (x,t) \in \Omega \times R, \tag{1}$$

$$u(t,x) = 0, (x,t) \in \partial\Omega \times R, \tag{2}$$

$$u(0,x) = u_0(x), x \in \Omega, \tag{3}$$

where $m \geq 1, R = [0,\infty)$ and $\Omega \subset R^n$ ($n \geq 1$ is a natural number) is a bounded domain with smooth boundary $\partial\Omega$, $f(u) = \pm|u|^{p-2}u, p \geq 2$. The problem describes the evolution of the population density of a species living in domain Ω, called the habitat. The term Δu^m models a tendency to avoid crowing and the reaction term $f(u) = u^{p-2}(a-bu)$ represents the condition of the population supply due to births and deaths. In the case $m = 1, f(u) = u(a-bu)$ the equation (1) are the Logistic equations. In the case of $f(u) = -|u|^{p-2}u$, we get the algebra decay by a differential inequality, and this improved the previous result. In the case of $f(u) = |u|^{p-2}u$, we construct a set, which is called stable set, and get the exponential decay for the solution with positive initial energy by Nakao's inequality, this result, to author's knowledge, is new. By the way, our methods can be extended to more general case, for example $|f(u)| \leq a|u|^{p-1} + b|u|^{q-1}$ in equation (1). Moreover, it can also be used to the general equations

$$\partial_t(b(u)) = div(a(u, \bigtriangledown u) + f(u).$$

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Key words and phrases. decay rates,algebraic decay, exponential decay, degenerate parabolic equations.

Study on stability of SIS epidemiological model with distributed delays

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Abstract: In this paper, we study an SIS epidemic model with distributed delays .By applying differential inequality technique , the existence of the disease-free equilibrium and the endemic equilibrium are proved. Some sufficient condition on global exponential stability of the disease-free equilibrium and local exponential stability of the endemic equilibrium are obtained.

Main conclusions: **some conditions independent of delays are derived.**

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Convergence of a discrete-time age-structured population toward a given steady state through controlled immigration

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Abstract

To explore the concept of stability in age-structured population with migration, a Markov transition matrix model is built, where age classes can be of different length, and the time step is not necessarily equal to the length of the age class. The conditions under which a vector of the model has a steady population structure are identified, as well as those under which the age structure converges to a given steady state, through a series of decisions or controls of letting immigrants in or stopping them. The decisions are expressed as vectors of immigration proportions. In the steady state, when the increment of population is proportional to its size, the age- or stage-structure remains unchanged between transitions.

Key Words: Age-structured Population, Stability, Matrix Model, Target-control

THE EFFECT OF POPULATION MOVEMENT ON DYNAMICS OF INFECTIOUS DISEASE

ZHANG SHAOLIN AND WEI MINGJUN

A SIS model is developed for the transmission of infectious disease by population movement among regions(or cities).The disease transmission model is formulated as a system of ordinany differential equations.The model exhibits tow equilibria,namely:a disease free equilibrium and a endemic equilibram.Some Threshold are identified and stability result are proved.Further,The result show that infectious disease,and even more so when interconnected to other ones and forming a system,can have a multipier effect on the epidemic. Other model with population constant mobile was introduced. the movement of susceptible and infected people from one patch to another patch is only moderately chance the number of infected people at the steady sate in each patch. but it is only moderately chance the total, steady state number of infected summed over all the patches.

infectious disease; basic reproduction number; population movement.

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Neural Network Modeling of Survival Process of Holometabolous Insect *

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ABSTRACT

Neural networks are flexible approximators for linear or nonlinear ecological systems. The objective of this study is to test the properties and performances of BP neural network and conventional models in modeling survival process of the holometabolous insect. BP neural network, empirical models, and probabilistic density functions were used to modeling the survival process of *Spodoptera litura* F. (Lepidoptera:Noctuidae). Simulation performances were compared among these models. Features for using BP neural network in ecological researches were discussed.

The results showed that BP neural network could be used to modeling survival process of the holometabolous insect. Survival dynamics, mortality distribution, and two-dimensional relationships may be simulated using the BP neural network. BP network performed better than empirical models and the probabilistic density functions such as normal function, logrithm-normal function, Cauchy function, and x^2 function, etc. In addition, BP network yielded more reasonable predictions than conventional models.

It was suggested that an optimized BP neural network should be built to modeling the details of ecosystem at the specific scale. To design a satisfied BP network, the desired ecological scale should be taken into consideration. The author takes the view that such network features as the numbers of hidden layers and neurons, and the desired accuracy and training epochs, etc., are actually different ecological scales. To recognize mechanisms and make predictions at the required scale, the corresponding settings should be fixed in BP neural network. An analysis towards the quantitative relationship between ecological scales and the settings of neural network may help to build an optimized BP network.

Neural networks used in ecological researches are focused on simulations and short-term predictions but not robotic applications. The author thus argues that the artificial neural network is a model more than an artificial intelligence or a machine learning technique in ecological and environmental researches.

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Mathematical modeling the pathway of human breast cancer

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ABSTRACT: the biological hypotheses into the multistage models that the age dependent dynamics of normal breast tissue, clonal expansion of intermediate cells and mutation rates to fit the age-specific incidentce of breast cancers in the surveillance, epidemiology, and end results (SEER) Registry. Our results suggest that loss of functions of instability genes is an early event in the timorigenesis which is useful for early diagnosis of breast cancer, the clonal expansion of intermediate cells must depend on the expression level of hormone of females which indicates that it is effective for hormone therapy to breast cancer for the female before her menopause and mutations in the genome of normal breast stem cells play more important roles than clonal expansions of intermediate cells in the tumorigenesis.

Backward bifurcation and global dynamics of an SIS epidemic model with general incidence rate and treatment*

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Abstract

An SIS epidemic model with treatment is proposed. The incidence rate of the model, which can include bilinear incidence rate and standard incidence rate, is a general non-linear incidence rate. The global dynamics of the model are studied and then we can understand the effect of the capacity for treatment. It is found that a backward bifurcation occurs and there exist bistable endemic equilibria if the capacity is low.

Key Words: Incidence rate; SIS; Backward bifurcation; Global stability; Limit system.

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A MARKOVIAN METAPOPULATION MODEL AND ITS APPLICATION

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The Markovian model proposed by Day and Possingham was modified in this paper so as to make it more suitable for the case of the metapopulation dynamics of two species of butterflies, Euphydryas aurinia and Melitaea phoebe which live in the same patchy world in Hebei province, China. The transition matrix is composed of two transition matrices which describe the extinction and colonization process respectively. The distribution and expected value of the metapopulation life time were calculated, the occupancy probability of each patch and the number of occupied patches under quasi-stationary distributions were also studied in this paper. The results show that Euphydryas aurinia has a classical metapopulation pattern while Melitaea phoebe has a source-sink metapopulation pattern which coincide with the conclusion obtained by the biological view. The importance of each patch and the effects of further patch loss were also investigated in the paper.

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Key words and phrases. Markovian model; Metapopulation; Quasi-stationary; Life time.

EXTINCTION AND PERMANENCE FOR A PULSE VACCINATION DELAYED SEIRS EPIDEMIC MODEL

TAILEI ZHANG AND ZHIDONG TENG

A delayed SEIRS epidemic model with pulse vaccination and bilinear incidence rate is investigated. Using Krasnoselskii's fixed-point theorem, we obtain the existence of disease-free periodic solution (DFPS for short) of the delayed impulsive epidemic system. Further, using the comparison method, we prove that under the condition $R^* < 1$, the DFPS is globally attractive, and that $R_* > 1$ implies that the disease is permanent. Theoretical results show that the disease will be extinct if the vaccination rate is larger than θ^* and the disease is uniformly persistent if the vaccination rate is less than θ_*. Our results indicate that a long latent period of the disease or a large pulse vaccination rate will lead to eradication of the disease.

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Key words and phrases. Disease-free periodic solution, Global attractivity, Extinction, Permanence, Pulse vaccination, Epidemic model, Fixed point, Threshold, Delay.

PREY-PREDATOR MODEL WHERE THE MATING FOR PREY IS RANDOM

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Abstract In this article a prey-predator model with sex structure in the prey population is proposed, where random mating, without the formation of permanent male-female couples, is the prevailing and only arrangement for propagation of the prey population. By mathematical analysis we find, that predation without sex bias can't alter the sex ratio of the prey and sex-biased predation can do, that when the birth rates of female and male prey are equal sex-biased predation can always eliminate periodic oscillation behavior, that large sex-biased predation rate can always eliminate oscillation behavior when the birth rates of female and male prey are not equal, and that whether the oscillation can be eliminated is determined by the sex-biased rate and the ratio of birth rates of male and female prey

Key words Two-sex; Sex-biased predation; Sex ratio; Periodic oscillation

Maximum Likelihood Estimation for Simplex Distribution Nonlinear Mixed Models via an EM Algorithm

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Abstract

Longitudinal continuous proportional data is common in many fields such as biomedical research, psychological research etc.. The percent decrease in glomerular filtration rate at different follow-up times from the baseline. As shown in Song and Tan (2000), such data can be fitted with simplex models. However, the original models of Song and Tan (2000) for such longitudinal continuous proportional data assumes a fixed effects for every subject. This paper proposes simplex distribution nonlinear mixed models to extend the models of Song and Tan (2000). Via treating the random effects in the models as hypothetical missing data and applying Metropolis - Hastings algorithm, this paper develops an EM algorithm with Markov chain Monte-Carlo method for maximum likelihood estimation in the models. The method is illustrated with the same data from an ophthalmology study on the use of intraocular gas in retinal surgeries in Song and Tan (2000) for ease of comparison.

Keywords: Simplex distribution, Nonlinear mixed models, Maximum likelihood estimates, MCEM algorithm, Metropolis-Hastings algorithm, Newton-Raphson iteration, Longitudinal proportional data.

The Model on Time-Space Dynamic For Aphids in Agricultural Eco-system

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Aphids in crop and forest are a group of small, sap-sucking pest insects which are serious pests in agriculture and forestry industry worldwide. The annual worldwide economic loss caused by aphids is estimated to be 5 billion. Aphids are represented by hundreds of species and are one of the main target insect groups in Integrated Pest Management. The one of important habit of aphids is mass, so the time-space dynamic of aphids population is mass, diffuse, and mass again and diffuse again go on, on till uniformity distribution in the field through investigation in fieldit is described as: (1) by author in 1991, which is model on damped vibrate modes, better than the Fourier Series model of population in citrus mite by Zhao Zhimo using index of crowd in 1983 as (2) The model by Zhao Zhimo is equal period and scope, fall short of the dynamic of insect, special piercing and sucking mouthparts hexapod. Whereas the model on damped vibrate is decreasing scope but equal period, it is also fall short of the dynamic of insect. So the model of damped vibrate will be changed as (3) the fig following. The experiment datum supports the model.

Keywords: Time-space dynamic, Aphids, Damped vibrate, Period and Scope.

Spreading speeds, traveling waves and global stability for biological evolution systems

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Abstract: In this talk, I will first give a brief review on asymptotic speeds of spread (in short, spreading speeds), traveling waves and their global stability for biological evolution systems with spatial structure. Then I will present the mathematical theory and methods of monostable and bistable waves for monotone systems. Finally I will discuss their applications to various deterministic models on biological invasion and disease spread.

A discrete S-I-R Model with general function of remaining susceptible probability *

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Abstract: This paper studies a discrete S-I-R disease transmission model, in the model the remaining susceptible probability is a general function $G(x)$ of infected population. The model is an extension of a discrete-time S-I-S model of [10], we consider the fluence of recovered population. We prove that the system is uniform persistence under some conditions and establish the conditions for the local stability and global stability of disease-free equilibria and endemic equilibria.
keyword: Discrete S-I-R model; Disease-free equilibria; Endemic equilibria; Uniformly persistence; Global stability

Disease Spread Model in Dynamic Networks

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ABSTRACT: A lot of complicated systems in the nature can be described with the form of networks. Among the research of networks, one important work is to research the propagate behavior of networks, which is of great theory value and realistic meaning. The spread of infectious disease among the social crowds, the prevalence of computer virus on Internet, information and rumour diffusion in the society is all shown as the form of disease spreading in the networks. Studying the propagate law of disease, finding out the effective disease control methods is an arduous and significance work。 At present, the research of disease spreads mainly carried on the static networks, different topological structures are studied in term of the critical value of propagating intensity. However, in the real situation, the individual will always be changing one's own position with the change of time constantly, but not has stayed and has not moved in where it is all the time, in addition, the influence of crowd's density to the spread of disease should be attended. For this reason, we add the two factors described above into the traditional disease propagating model and carried on artificial simulation。 In our model, crowd is distributed in a two-dimentional regular network which looks like a chess board. In order to have a comparation, we study separately the disease's spreading laws while the crowd flowing and staying in the network. When the crowd can move around in the network we call it dynamic network , or we call it static network . Each individual can only spread the disease to their four neighbors with certain probability, and each individual can only move by four direction randomly. Every step, the patients can spread the disease to their neighbors with probability p1 , at the same time, the patients can be cured with probability p2. The crowd is distributed in the grids sparsly, the average count of individuals each grid holding is called crowd density , written as d (d<1). By artificial simulation, we investigate the influence on the spreading of disease caused by p1,p2 and d. Conclusions are carried out as the following:

1. When disease spreading reach the steady state, the final infection rate will increase with the rise of the infection probability p1, and drop with the rise of the cure probability p2.
2. When disease spreading reach the steady state, the final infection rate will increase notably with the rise of the density of crowd.
3. Flowing crowd is easier to propagate disease than steady crowd, which can be found by the final infection rate.

Key words: dynamic networks， disease spread，infect probability，cure probability, crowd density

SIRS disease spreading model based on two dimensional regular lattice

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Abstract：A SIRS(Susceptible-Infected-Recovered-Susceptible) disease spreading model based on two dimensional regular lattice is proposed. In this model , the effects of crowd-density d 、spread efficiency λ and the moving activity of agents on the spreading of disease is researched. The theoretical analyse and analog simulation shows that there is a critical value $(\lambda d)_c$ in this model, and only when the product of spread efficiency and crowd density goes beyond $(\lambda d)_c$ the disease can spread in crowd continuously and steadily . Besides, the moving activity of agents can promote the spreading of disease at the case of low crowd density . According to these results, the measures are presented to prevent the spreading of disease.

Key words：Susceptible-Infected-Recovered-Susceptible model；disease spreading；analog simulation

Kinematics Analysis and Imitation for German Shepherd Dog

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In the recent years, the number of robots has increased significantly to about 4 or 6 times. Researchers have studied the biological nature of animals and then designed a bionic model based on the gait and structure of the animal. In this paper, a German shepherd dog was selected for bionic modeling and VICON MX 3D motion capture system was used to get kinematics data of the animal in real life. The manner of the limb's locomotion was studied when the dog was jogging, trotting and running, and possible factors affecting the dog's gait were analyzed. Based on the kinematics data, an ideal bionic model was designed and then analyzed to assess the static stability of the dog in jog gait. Between the touchdown and empty out phases, the joint locomotion of single leg by positive and contrary kinematics was observed and the results were analysed. Finally, ADAMS software was used to imitate the model in jog gait by kinematics. From the imitation results, the model's locomotion compared to the gait style of German shepherd dog in real time was good, and testified that the model is feasible.

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PERMANENCE OF SPECIES IN NONAUTONOMOUS DISCRETE LOTKA-VOLTERRA COMPETITIVE SYSTEM WITH DELAYS AND FEEDBACK CONTROLS

X. LIAO, Z. OUYANG, AND S. ZHOU

A nonautonomous N-species discrete Lotka-Volterra competitive system of difference equations with delays and feedback controls is considered. New sufficient conditions are obtained for the permanence of this discrete system. The results indicate that one can choose suitable controls to make the species coexistence in the long run. Moreover, we give some examples to illustrate the feasibility of our result which can be well suited for computational purposes.

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Key words and phrases. Key Words and Phrases: positive solution, delays; Lotka-Volterra discrete system; permanence; N-species; with feedback controls .

Equilibrium Stability of a Class Discrete Epidemic Models with age and Infectious Age Atructure

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In this paper a class of discrete epidemic models is formulated. The basic reproductive number R_0 of the model is defined. The dynamical behavior of this model is studied. It is proved that disease free equilibrium is globally asymptotically stable if $R_0 < 1$, and it is unstable if $R_0 > 1$. The existence and uniqueness of the endemic equilibrium is obtained if $R_0 > 1$, and the globally asymptotical stability of the endemic equilibrium is proved for the SIS model with age structure. The local and global stability of the endemic equilibrium for the model with infectious age structure is investigated by numerical simulation.

An Eco-epidemiological Model with Stage Structure

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Abstract: An eco-epidemiological model with stage structure is studied in this paper. The prey individuals are divided into two stages and it is assumed that the infected predator can't to prey. The boundness of solutions and the existence of the disease-free equilibrium and endemic equilibrium are obtained. The conditions of locally asymptotic stability of equilibriums are obtained by discussing the eigenvalue equation of the equilibriums.Futhermore, the globally asymptotic stability of disease-free equilibriums and the conditions under which the model hold a hopf bifurcation are discussed. And the numerical simulation is given.

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The Relevant Post Correspondence Problem About A General Partial Sticker Operation *

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Abstract

In this paper, we define a general sticker operation of DNA sequences.Then we give the concept of the post correspondence problem about incomplete double stranded molecules for this general partial operation . Furthermore, we show that the post correspondence problem about incomplete double stranded molecules is undecidable .

Keywords: DNA computing; sticker operation;post correspondence problem;undecidable

2. 蛋白质分类的球面结构曲线

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蛋白质是生命科学中研究的重要对象，而蛋白质的功能与作用是由它的结构决定的，蛋白质折叠问题也即蛋白质结构预测问题是生物信息学领域的核心问题之一。随着人类基因组测序工作的完成，蛋白质的功能研究已经提到日程上来，这标志着功能基因组，即后基因组时代的到来。蛋白质的功能和结构具有密切的关系，只有处在一定的空间结构中蛋白质分子才能够发挥其特定的生物学功能。自20世纪50年代以来，Anfinsen等人就发现蛋白质的空间折叠结构取决于构成该蛋白质的氨基酸序列，也就是说蛋白质的空间折叠结构的全部信息都隐藏在蛋白质的线性结构中，即氨基酸序列中。因此，从理论上讲，我们可以根据蛋白质的氨基酸序列来预测蛋白质的空间折叠结构。

由于蛋白质是一类结构复杂与功能多样的生物大分子,由 20 种氨基酸组成,因此, 蛋白质可看作 20 个字母上的字，且恰好与三联子编码方式相适应。从而，

可利用氨基酸排列顺序中的信息来对蛋白质域结构类进行分析。本文以 2 维三联子编码方式对蛋白质进行编码，再建立至球面的投影，得到相应的球面曲线，达到利用球面曲线的类型特征给出蛋白质序列的结构刻画图，并进而对蛋白质的功能和结构进行预测分析。

同时，利用此法对基因病变导致蛋白质结构变异图进行了描述分析。

关键词：蛋白质；编码；球面曲线；预测分析。

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A DYNAMIC MODEL OF LARGE-SCALE INSECT CELL INFECTION AT LOW MULTIPLICITY OF INFECTION

LEI DENG, XIUFEN ZOU* AND JINGYING TAN

Virus-like particles (VLPs), which produce from the baculovirus insect cell expression system, constitute potential vaccines for prevention of the epidemic diseases. The expression efficiency of the baculovirus insect cell system used for VLPs production is closely related with the dynamics of infection. When a large scale production process for VLPs with recombinant baculovirus-infected insect cells is designed, a low multiplicity of infection (MOI) strategy was used to overcome an extra virus amplification step, undesirable in industrial production, and to minimize the virus passage effect. In a large scale production process for VLPs with a low MOI, how is the relation of the highest virus titre and culture conditions determined quantitatively? When is the optimal harvest time? To address these issues, a new mathematical model that describes the dynamic process of cell infection with baculovirus at MOI has been developed. The model consider the different stages of the infected cells, including the eclipse period, the budding of viral particles from the infected cells, their attachment to non-infected cells and the initiation of a new infection cycle. The results from theoretical analysis of stability of the steady state solution of the model and numerical simulation show that the harvest time is dependent on the MOI, the attachment coefficient, and a quantitative relationship with the cell yield is elucidated. These results provide useful instruction for the industrial scale production of VLPs vaccines.

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Key words and phrases. dynamic model, low multiplicity of infection,insect cells;

A mathematical model for the control and eradication of a wood boring beetle infestation

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Abstract

We propose a mathematical model for an infestation of a wooded area by a beetle species in which the larva develop deep in the wood of living trees. Due to the difficulties of detection, we presume that only a certain proportion of infested trees will be detected and that detection, if it happens, will occur only after some delay which could be long. An infested tree once detected is immediately cut down and burned. The model is stage structured and contains a second time delay, the development time of the beetle from egg to adult. There is a delicate interplay between the two time delays due to the possibility in one case for a larva to mature even in a tree destined for destruction. We present conditions sufficient for infestation eradication and discuss the significance of the conditions particularly in terms of the proportion of infested trees that need to be detected and removed. If the infestation is successfully eradicated there are always a number of trees that completely escape infestation and we compute lower bounds and an approximation for this number. Finally, we present the results of some numerical simulations.

This is a joint work with Stephen Gourley

TIME-LIMITED MANAGEMENT STRATEGIES OF SINGLE-SPECIES WITH ALLEE EFFECT

HONGJIAN GUO, LANSUN CHEN, AND XINYU SONG

Time-limited management strategies of single-species with Allee effect according to the initial density of the species, which can be described by impulsive differential equation with initial and boundary value problem, are presented. By means of comparison principle and method of upper and lower solutions, the boundary value problems of impulsive management are discussed. According to the initial density of the species, there are two kinds of models: model with release and model with harvesting. The corresponding sufficient conditions under which the corresponding model has a solution or no solution are obtained. For model with release, if other parameters are given, the population of release is estimated. For model with harvesting, the times of impulsive harvesting is also estimated. From the point of view of ecological meanings and artificial control in finite time, discussions and corresponding numerical simulations about the results obtained in this paper are given.

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Modelling aspects of solid tumour growth

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Abstract: In recent years there has been a significant paradigm shift in mathematical modelling in biological systems towards integrative modelling across a large range of spatial and temporal scales. A typical example of this is the growth of cancer where genetic mutations lead to abnormal cell behaviour which leads to a change in the cell microenvironment which in turn feeds back on cell behaviour. Within this context a number of modelling problems in avascular and vascular tumour dynamics will be discussed.

The Complete Classification for Dynamics in a Homosexually-transmitted Disease Model

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Abstract A sexually-transmitted disease model for two strains of pathogen in a one-sex, heterogeneously-mixing population was proposed by Li et al in [19]. The sufficient and necessary conditions for coexistence and the sufficient conditions for stability of the boundary equilibria were provided. This paper will present a thorough classification of dynamics for this model in terms of reproductive numbers of infection in strains 1 and 2 and the numbers of secondary cases. This classification not only solves a conjecture proposed in [19] but also gives the sufficient and necessary conditions for the competitive exclusion.

Key words and phrases: sexually transmitted disease, pathogen strains, competitive exclusion, global stability

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Abstract

The selective pressure induced by anti-viral drugs on their target virus may allow drug-resistant strains to survive and replicate. While these resistant strains may initially emerge with compromised fitness, mutations that compensate for this can arise to produce a resistant strain with only slightly impaired replication and transmission fitness compared to the original wild type strain. We will describe a delay-differential model for the spread of pandemic influenza that couples between host transmission of the disease to within-host dynamics of viral replication, including these compensatory mutations. Our model predicts that high treatment levels can encourage a resistant outbreak to occur, by surpressing the spread of the wild type infection. The optimal treatment level, which allows maximal control of the wild epidemic while still minimizing the number of resistant cases, increases with the reproductive number of the pandemic. Therefore, other control measures, such as increasing social distance, or earlier diagnosis and treatment of infection can still encourage the outbreak of the resistant strain, even if overall treatment levels are kept modest.

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