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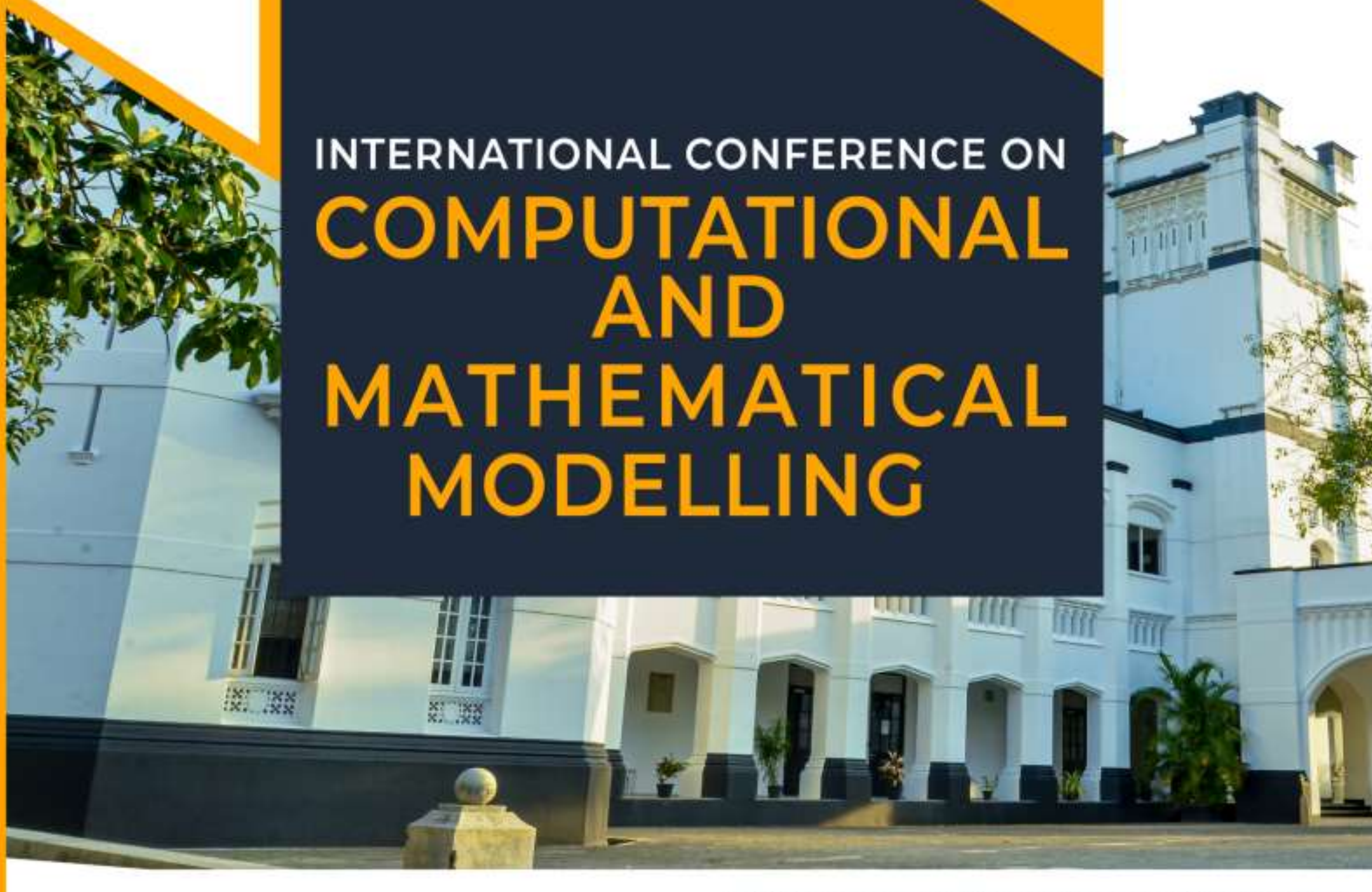

CENTRE FOR MATHEMATICAL MODELLING
DEPARTMENT MATHEMATICS
FACULTY OF SCIENCE
UNIVERSITY OF COLOMBO
SRI LANKA

Keynote Address

Keynote Address

Professor Thomas Göetz is the Treasurer and a Member of the Board of ECMI (European Consortium for Mathematics in Industry). He has served as a coordinator for DAAD-Network several times within the last two decades. Prof Götz has contributed to the field of Industrial Mathematics with his works on Interactions of Fibers and Flow: Asymptotic, Theory & Numeric and Habilitation in Mathematics: Asymptotic Methods for Fluid Problems. He is currently also the Vice Dean for Research and Young Scientists at the University of Koblenz-Landau.

Prof. Thomas Goetz

University of Koblenz
Germany

Social Models and Epidemiology

The past COVID—pandemic has shown the need for mathematical models of disease dynamics. Worldwide, researchers have developed models and tried to evaluate the effect of potential countermeasures like lock-down, testing or vaccinations. However, disease dynamics is not just driven by individual factors but also social aspects. Living conditions, households' structures or even beliefs and media consumption play a crucial role in determining the progression of the epidemic and for the impact of counter measures. Individual opinions on the disease and influence the transmission dynamics and are influenced themselves by the prevalence of the disease in the population. In this talk we will discuss the combination of epidemiological models with social aspects based on some exemplary situations.

Invited Talks

Prof. Asep K. Supriatna is a Professor in the Department of Mathematics, Padjadjaran University, Indonesia. He holds a position as the head of the Biomathematics Research Group. His primary research is in Mathematical Bioeconomic Modeling, Mathematical Epidemiology, and Industrial Mathematics. His education background includes Post Doctoral (ITB & University of Twente, The Netherlands, 2006-2008); Doctoral (Applied Mathematics, University of Adelaide, Australia, 1998); Master (Mathematics, ITB, 1992); Bachelor (Mathematics, UNPAD, 1988).

Prof. Asep K. Supriatna

Padjadjaran University
Indonesia

Discretisation and MSY of Some Population Models

Overfishing is a global environmental problem that risks fisheries since much of the fish stock of the fisheries has already reduced to below a tolerable level. One of the solutions that is often implemented in fishery management is by calculating the value of Maximum Sustainable Yield (MSY) as the maximum tolerable harvest that can be taken out from the natural stock without harming the population over an indefinite period of time. A proper tool used for computing the MSY is needed to support the fishery manager in solving this decision-making problem. In this talk, we present some methods to estimate the MSY for harvested fish populations. We consider various models of the growth of the populations by considering different biological and spatial structures of the underlying populations. The method is able to estimate this MSY metric using the known catch and effort data of the fisheries. A known standard procedure is modified to fit those data by considering a more complex biological interaction such as a logistic metapopulation and a population with different levels of intra-specific competition. We present the discretization formulas for these populations to estimate their Maximum Sustainable Yields.

Prof S. Sundar is a Chair Professor, IIT Madras and Director, National Institute of Technology, Mizoram, India. He is a fellow of the prestigious Indian Academy of Mathematical Modeling and Simulation and is a distinguished alumnus of TU Kaiserslautern, Germany. In 1989 he obtained a Ph.D. in Mathematics from IIT Madras and has made over 75 publications ever since. His areas of research are numerics for PDEs, Mathematical modeling, and numerical simulation. Currently, he is supervising 9 Ph.D. students, and over 15 students have completed their Doctoral degrees under him.

Prof S. Sundar

Indian Institute of Technology Madras (IIT Madras)
India

A Shock-Capturing Meshless Geometric Conservation Weighted Least Square Method for Solving Shallow Water Equations.

The shallow water equations are numerically solved to simulate free surface flows in two-dimension (2D). The convective flux term in the shallow water equations needs to be discretized using a Riemann solver to capture shocks and discontinuity for certain flow situations such as hydraulic jump, dam-break wave propagation, or bore wave propagation. The approximate Riemann solver can capture shocks and is popular for studying open channel flow problems with the traditional mesh-based methods. However, meshless methods can work on structured and unstructured grids and even for points irregularly distributed over a computational domain. Moreover, approximate Riemann solvers are not reported to be implemented within the framework of meshless methods for solving the shallow water equations. Therefore, we have proposed a numerical method, namely, a shock-capturing meshless solver for the shallow water equations for simulating 2D flows on a highly variable topography even in presence of shocks and discontinuity. The HLL (Harten-Lax-Van Leer) Riemann solver in the proposed meshless method is used to evaluate convective flux. The spatial derivatives in the shallow water equations and the reconstruction of conservative variables to calculate flux terms are computed using a geometric conservation weighted least square (GC-WLS) approximation. The proposed meshless method is tested for a range of numerically challenging problems and laboratory experiments.

Prof. Rana Parshad is an interdisciplinary and applied mathematician interested in Mathematical Biology and population dynamics. He received his bachelor's degree in mathematics at New York University in 2001, Master's degree in Applied Mathematics at the University of Maryland at College Park in 2004, and my PhD in Mathematics at Florida State University in 2009. From 2009-2013. He completed postdocs at Clarkson University in Potsdam NY, and then at the King Abdullah University of Science and Technology (KAUST) in Saudi Arabia. He was an Assistant Professor in the Department of Mathematics at Clarkson University from 2013-2018.

Prof. Rana Parshad

Iowa State University
USA

Some recent pest management approaches for the control of the soybean aphid.

The Soybean aphid is an invasive pestiferous species that is the chief pest on soybeans in the north-central United States. In this talk, we survey recent approaches to pest management tactics for its control. These approaches are formulated via non-autonomous differential equations. In particular, we discuss the adoption of our approaches in light of a changing climate. This is joint work with Aniket Banerjee and Urvashi Verma at Iowa State University, and Margaret Lewis and Andy Michel at Ohio State University.

Prof. Agus Suryanto received both a master's degree in Engineering Mathematics (1999) and PhD degree in Applied Mathematics (2003) from the University of Twente, The Netherlands. Currently, Agus Suryanto is a Full Professor in Applied Mathematics, Department of Mathematics, University of Brawijaya, Indonesia. His present research interests are applied mathematics, applied dynamical system, mathematical population dynamics (mathematical ecology and mathematical epidemiology), including continuous and discrete systems.

Prof. Agus Suryanto

University of Brawijaya
Indonesia

Dynamically Consistent Discrete Population Models

Continuous dynamical systems have been widely applied to model various kinds of problems related to population dynamics. In general, the population dynamics models are written in the form of systems of nonlinear differential equations. These systems of nonlinear differential equations usually do not have solutions in close – form. Thus, we usually apply numerical methods to find the approximate solutions. The numerical solution should converge as the time step goes to zero. In addition to convergence, it is also desirable to preserve the dynamical properties of the system. These properties are usually associated with the positivity and boundedness of the population, asymptotic stability, periodicity of solution, etc. There are many kinds of numerical methods for solving differential equations, for example, the Euler method, the Runge-Kutta method, the predictor-corrector method, and others. It was shown in much literature that standard methods such as the Euler method or Runge-Kutta methods fail to preserve the dynamical properties of the original continuous model. Here, we discuss a nonstandard finite difference (NSFD) method The NSFD method was first introduced by Mickens to overcome the weaknesses of standard finite difference (SFD) or Euler method. We show the NSFD method can maintain the dynamical properties of the original models. Furthermore, for some simple cases, the NSFD produces solutions which are the same as their exact solutions. To demonstrate the effectiveness of the NSFD method, we compare our numerical results using the NSFD method with those of the Euler method and Runge-Kutta method. Such comparison shows that the NSFD method produces more accurate solutions than the Euler method and Runge-Kutta method.

Kuncham Syam Prasad is currently working as a Professor & Head in the Department of Mathematics, Manipal Institute of Technology, Manipal Institute of Higher Education, Institute of Eminence (Deemed to be University), Manipal, India. His research interests are on Algebra (Rings, Nearrings, Module Theory) and Discrete Mathematical Structures.

Prof. Kancham Syam Prasad

Manipal Institute of Technology
India

Graphs with respect to Essential Ideals and Superfluous ideals of N-Groups

Nearrings are generalized rings. We consider a module over a right nearring (known as N-group). The notions essential submodule and its dual notion superfluous submodule are well-known in modules over rings. In this talk, we introduce the notions essential ideal graph and superfluous ideal graph of N-group (say, G) and prove some combinatorial properties involving diameter, connectivity, completeness, etc. with some illustrations.

Prof. Ratnasingham Shivaji received his Ph.D. in Mathematics from Heriot-Watt University in Edinburgh, Scotland in 1981 and his B.Sc. Special Degree in Mathematics (first-class honors) from the University of Peradeniya, Sri Lanka in 1977. His area of specialization is partial differential equations, in particular, nonlinear elliptic boundary value problems. His research has been funded by the National Science Foundation and the Simon's Foundation. Currently, he is serving as the PI on an NSF Mathematical Ecology grant. Prof. Shivaji is a Fellow of the American Mathematical Society. He is also the recipient of the 2020 Mathematical Association of America Southeastern Section Award for Distinguished University Teaching of Mathematics. To date, Shivaji has directed one postdoctoral student and nineteen Ph.D. students (17 graduates, 2 current). He is currently the Helen Barton Excellence Professor of Mathematics at the University of North Carolina at Greensboro (UNCG). Prior to joining UNCG in 2011, Shivaji served for twenty-six years at Mississippi State University, where he was honored as a W.L. Giles Distinguished Professor.

Prof. Ratnasingham Shivaji

University of North Carolina Greensboro
USA

On the Effects of Density-Dependent Emigration on Ecological Models with Logistic and Weak Allee Type Growth Terms

We analyze the structure of positive steady states for a population model designed to explore the effects of habitat fragmentation, density dependent emigration, and Allee effect growth. The steady state reaction diffusion equation is:

$$-\Delta u = \lambda f(u);\ \Omega$$

$$\frac{\partial u}{\partial \eta} + \gamma\sqrt{\lambda} g(u)u = 0;\ \partial\Omega$$

where $f(s) = \frac{1}{a}s(1-s)(a+s)$ can represent either logistic-type growth ($a \geq 1$) or weak Allee affect growth ($a \in (0,1)$), λ , $\gamma > 0$ are parameters, Ω is a bounded domain in R^N; $N > 1$ with smooth boundary $\partial\Omega$ or $\Omega = (0,1)$, $\frac{\partial u}{\partial \eta}$ is the outward normal derivative of u, and $g(u)$ is related to the relationship between density and emigration. In particular, we consider three forms of emigration: density independent emigration ($g = 1$), a negative density dependent emigration of the form $g(s) = \frac{1}{1+\beta s}$, and a positive density dependent emigration of the form $g(s) = 1 + \beta s$, where $\beta > 0$ is a parameter representing the interaction strength. We establish existence, nonexistence, and multiplicity results for ranges of λ depending on the choice of the function g. Our results shed light on the complex interactions of density dependent mechanisms on population dynamics in the presence of habitat fragmentation.

Prof. Harikrishnan Panackal is an Additional Professor in the Department of Mathematics, Manipal Institute of Technology, Manipal Academy of Higher Education, Institute of Eminence Deemed to be University, Manipal, India. His research interests are in Functional Analysis, Algebra and Discrete mathematics.

Prof. Harikrishnan Panackal

Manipal Institute of Technology
India

Computation of prime ideals in meet hyperlattices

The notion of prime ideal and its characterizations in classical lattices are well known. Hyperlattices are the generalizations of a classical lattice, wherein one (or both) of the classical operations is/are replaced with hyperoperation/s. In this presentation, we define the generalizations of prime ideals such as 2-absorbing hyperideal, primary hyperideal, 2-absorbing primary hyperideal, weakly prime hyperideal etc. We provide suitable examples to distinguish all these classes and the related results.

Wolfgang Bock is an Associate Professor at Linnaeus University in Växjö, Sweden. His research interests are in complex systems and Stochastic Analysis. He has several research contributions in the field of Mathematical Epidemiology particularly in modeling Dengue and COVID-19.

He is a member of the MOCOS International Research Group for COVID-19 Modeling and is currently head of a project group developing an agent-based model for disease spread in a synthetic population of Germany.

Dr. Wolfgang Bock

Linnaeus University in Växjö
Sweden

Modelling Disease in Heterogeneous Populations

The last pandemic has shown that at the beginning of an outbreak, classical differential equation models, such as the compartmental model of Kermack and McKendrick, fail to give a good estimate of how a disease is spreading in a population. This is because a classical population is not well mixed, but contacts and transmission are rather heterogeneous quantities based on different attributes of the infectious and infectee.

On top of this, data is also in no way accessible in a homogeneous way. It is rather unclear what part of the information is available and how trustworthy it is.

Both considerations should change our perspective on disease modelling.

In this talk, I will give an insight into how to model disease in a heterogeneous population and why pandemic preparedness is also something that is relevant for Mathematics.

Dr. Ikha Magdalena is an Associate Professor in the Faculty of Mathematics and Natural Sciences at Institut Teknologi Bandung, Indonesia. Her research focuses on numerical modeling for coastal dynamics and protections. She has made significant contributions to her field, as evidenced by the publication of several papers in reputable academic journals and conferences. Dr. Magdalena is also actively engaged in the practical implementation of her research in coastal areas. Her initiatives include the strategic planting of mangroves and the construction of hybrid structures designed to protect these vital ecosystems. This hands-on approach underscores her commitment to making a tangible difference in environmental conservation.

Dr. Ikha Magdalena

Institut Teknologi Bandung
Indonesia

Analytical, Numerical and Experimental Studies of Wave Attenuation by Vegetation

Coastal protection is an important issue that needs to be addressed as soon as possible. In many cases, protection of the coastal area is approached from an engineering perspective, such as creating an artificial breakwater or hard structure such as a sea wall. However, this approach has resulted in harm to underwater ecosystems. Vegetation such as seagrass and mangrove forest can act like a natural barrier offering an alternative to hard structures for coastal defence. The attenuation of waves by vegetation can be observed through the decrease of wave height. Attenuation is a general term that refers to any reduction in the wave's energy. In this research, we present a mathematical model to investigate wave attenuation phenomenon by vegetation. This model is based on the Shallow Water Equations modified to account for attenuation by vegetation through an additional friction or diffusion coefficient. To accommodate the dispersive effect that appears in short waves, we modify the model by adding the hydrodynamic pressure. This model can be solved numerically using a free-damping-error method. The advantage of this model is that it not only covers the wave attenuation of a long wave but also a short wave. The computational model has been tested against analytical solutions for simple cases and against laboratory measurements for more complicated cases. Preliminary results show good agreement and show that vegetation can decrease the amplitude of the incoming wave. The final paper will present the theory and results, identifying the key parameters that determine wave attenuation.

Dr. S. Narayanamoorthy holds eighteen years of teaching and research experience from various institutes. He has guided 40 MPhil and 17 PhD awarded candidates. Currently, there are 6 candidates doing PhD under his guidance. In 2001, he completed his postgraduate degree, consecutively he completed Master of Philosophy in 2002 in Mathematics from Loyola College, Chennai, India. Later in 2008, he earned his doctoral degree (PhD) in Mathematics from Loyola College, Chennai, India. His research specializations mainly focused on Fuzzy Mathematics and Decision Science. In which, he has published more than 180 articles in various SCI /SCIE /Scoupus journals.

Dr. S. Narayanamoorthy

Bharathiar University
India

A Fuzzy Strategy for Decision Making

Fuzzy Multi-Criteria Decision Making (MCDM) is a sophisticated computational framework that addresses the complexities of decision problems involving multiple conflicting criteria and uncertainties. Unlike traditional decision-making models that rely on crisp, precise data, this approach integrates fuzzy logic principles with MCDM techniques to handle incomplete and vague information inherent in real-world decision scenarios. It enables decision makers to communicate options and uncertainties in a more natural and human-centered manner by using fuzzy sets and linguistic variables. By combining degrees of truth rather than binary outcomes, fuzzy decision systems enable more flexible and nuanced decision-making processes. Whereas the various MCDM methods provide a flexible way to analyze and prioritize alternatives based on multiple criteria, accommodating the subjective and context-dependent nature of decision criteria. This amalgamation of fuzzy logic and MCDM enhances decision robustness in diverse fields, some of which includes, environmental management, healthcare, engineering and energy planning. These diverse applications highlight the versatility and effectiveness of fuzzy MCDM in addressing decision-making challenges in various fields. In particular, this talk will describe how obscure MCDM is used in remote applications such as rice mill workers and silk weavers in Tamil Nadu, India. In addition, recent years have seen an increasing number of different approaches addressing different decision situations in MCDM. A few contemporary techniques are CODAS, MCRAT, EXPOREM, RATMI, and so forth. These different MCDM methods provide decision makers with a better toolbox to navigate the intricacies of decision problems in different domains, accommodating different preferences, uncertainties and complexities.

Dr. Deepa Sinha is currently working as a professor at South Asian University, New Delhi and received PhD from Delhi University, India in Applied Mathematics, 2007. She worked at Khalsa Girls Degree College (1996-1999), Delhi College of Engineering (1999-2004), Banasthali University (2004-2012), Delhi Technological University (2012). She obtained Ph.D. degree on a topic “A New Frontiers in the Theory of Signed Graphs”. She has refereed several research papers for National and International Journal of high impact factor like Discrete Applied Mathematics, Graphs and Combinatorics, International Journal of Physical Sciences etc. She has more than 50 research papers to her account in journals of high impact factor.

Prof. Deepa Sinha

South Asian University
India

Encryption using signed graphs

The encryption and decryption of sensitive information have become increasingly important in today’s digital age. In this paper, we explore the use of signed Cay-ley graphs, along with a private (symmetric) key, to securely encrypt and decrypt the edges of the graph.

Dr. Jagdish Chand Bansal is an Associate Professor (Senior Grade) at South Asian University New Delhi and Visiting Faculty at Mathematics and Computer Science, Liverpool Hope University UK. He also holds visiting professorship at NIT Goa, India. Dr. Bansal obtained his PhD in Mathematics from IIT Roorkee. His Primary area of interest is Swarm Intelligence and Nature Inspired Optimization Techniques. Recently, he proposed a fission-fusion social structure-based optimization algorithm, Spider Monkey Optimization (SMO). He is the editor (editor-in-chief) of the journal MethodsX published by Elsevier, the series editor of the book series Algorithms for Intelligent Systems (AIS), published by Springer and the general secretary of the Soft Computing Research Society (SCRS). He has also received Gold Medals at UG and PG levels.

Dr. Jagdish Chand Bansal

South Asian University
India

Drone Swarm: Concept, Challenges and Applications

Recently, swarm intelligence has emerged as an efficient problem-solving strategy. An interacting autonomous group of drones assigned to perform a/some task(s) is usually referred to as a drone swarm. Swarms of drones are a fundamental future agenda and will be adopted with time. The most crucial challenge for drone swarm is the inter-drone communication topology. Apart from the various possible inter-drone communication topologies, this talk will discuss the formal definition and requirements of the drone swarm. The types of drone swarms and the potential applications of drone swarm will be addressed.

Dr. Saroj Kumar Sahani is working as an Associate Professor at the Department of Mathematics, South Asian University, Chanakyapuri, New Delhi, India. Dr. Saroj's research involves the use of Differential Equation, Delay Differential Equation and Impulsive Delayed Differential Equation to model the biological, environmental and virological problems taking account of competition of species, age groups, impulsive perturbation etc. and predict their long-time behavior using tools like stability, bifurcation. The complex dynamical behavior of the system arising out of these effects is one of the key motives to explore in these studies. He has more than four years of teaching experience in teaching various UG and PG courses.

Dr. Saroj Kumar Sahani

South Asian University
India

A Delayed Model for Bacteria-Bacteriophage Interaction

We introduce a delayed model of Bacteria-Bacteriophage interaction involving the two life cycles of bacteria. The lytic path cycle is very common, and the lysogenic cycle is the other path often followed. Since every infection process involves some kind of time lag, we assume one of the times lag due to the latency period in this bacteria-bacteriophage model. Another time lag is assumed for the lysogenic phase before bacteria goes into the lytic phase and then to lysis. The underlying mathematical model is analysed by local stability analysis to study the local behaviour of the solution and some numerical analysis has been performed to check the validity of conditions and predict the model equation's long-term dynamics.

Dr. Q.M. Danish Lohani (Member, IEEE) received the PhD degree from the Department of Mathematics, Aligarh Muslim University, India, in 2009. He is currently working as an Associate Professor with the Department of Mathematics, South Asian University, India. He has published more than 50 scientific articles in well-known journals, including IEEE Transactions on Fuzzy Systems, Applied Soft Computing, Chaos, Solitons and Fractals, and reputed conferences, such as Fuzz-IEEE, IEEE-CEC, and IJCNN. His current research interests include study of both theoretical and application aspects of fuzzy, intuitionistic fuzzy, type-2 fuzzy sets, operators, and summability theory. He is a member of the IEEE Computational Intelligence Society and the IEEE Computer Society.

Dr. Q.M. Danish Lohani

South Asian University
India

Generalized Fuzzy TOPSIS for Hospital location Problem.

The hospital location problem of Istanbul city of Turkey is considered for the study. The hospital selection under combating criteria involves uncertainty and hesitancy due to insufficient equipment, low hospital- patient capacity, lack of specialized human resources, and high infection rates in hospitals. We study hospital selection as a multicriteria decision- making (MCDM) problem in which membership and non-membership values are allocated to the hospitals. A popular decision-making technique called TOPSIS is used to rank the alternatives over conflicting criteria to attain a compromised solution. Here, an AIFS variant of the TOPSIS is proposed with the help of a correlation coefficient. It is validated that the proposed method is capable of selecting the best hospital for a patient.

Dr. Navnit Jha is working as an Associate Professor at the Department of Mathematics, South Asian University, Chanakyapuri, New Delhi, India. He obtained a PhD degree in Numerical Analysis from the University of Delhi in 2004. He has been awarded the Royal Society of Edinburgh Fellowship 2018, Polish Academy of Science Fellowship 2014, Best Teaching Award 2010, CSIR-NET-JRF 2002, and National Scholarship 1993. He supervised three Ph.D. students in the area of high-performance computing and differential equations. More than fifty research papers in the journal of international repute are there in his credit.

Dr. Navnit Jha

South Asian University
India

Fuzzy Component Scheme for Differential Equations

Using a fuzzy transform approach, we analyse two-point boundary-value problems with discontinuous forcing functions. At the inside mesh locations, this framework applies a fuzzy transform that provides second-order precision approximations of solutions. A three-point linear combination of solution values is used to locally arrange the fuzzy components and the triangle base function. This results in a tri-diagonal Jacobian matrix that is efficiently computed in space and time. It is simple to derive solution approximations via fuzzy components by a tri-diagonal matrix inversion because a linear system links solution values and fuzzy components. A cubic spline interpolating polynomial can be used to establish an approximate analytical solution from the supplied data with fuzzy components easily, in addition to the numerical answer. Maximum and integrated absolute errors are used to calculate the error estimates for numerical and approximate analytical solutions.

Dr. Pratima Rai is working as an Assistant Professor at the Department of Mathematics, University of Delhi, New Delhi, India. She obtained a PhD degree from Panjab University Chandigarh in 2013 on the topic “Numerical analysis of singularly perturbed differential-difference turning point problems. She got the best paper award in Chandigarh Science Congress, Swami Ramananda Teerth Marathwada University in the year 2011 and was awarded the CSIR-NET-JRF in 2009. She is an excellent numerical analyst and supervised many research scholars in the area of computational method of differential equations.

Dr. Pratima Rai

University of Delhi
India

Uniformly Convergent Hybrid Scheme for Singularly Perturbed Delay Problems with Integral Boundary Condition

We study convection–diffusion type singular perturbation delay problem with an integral boundary condition. The analytical solution reveals a weak interior layer, alongside the boundary layer at the domain's right end. A priori estimates on the exact solution are provided, facilitating error analysis. The numerical approach employs a hybrid finite difference scheme implemented on a generalized Shishkin mesh. The proposed scheme demonstrates nearly second-order parameter uniform convergence. Numerical experiments are conducted to validate the theoretical findings.

Dr. Venu Gopal is working as an Assistant Professor at the Department of Mathematics, Zakir Husain Delhi College. University of Delhi, New Delhi. He obtained a PhD degree from University of Delhi and served as a Post-doctoral Fellow at Brown University, USA. His research area is discontinuous Galerkin method for partial differential equations and has published many research papers in the journal of international repute.

Dr. Venu Gopal

University of Delhi
India

Discontinuous Galerkin Method for Hyperbolic Equations

The historical background of the Discontinuous Galerkin Method and some recent developments of DG method for hyperbolic equations are described. These developments analyse and test a Discontinuous Galerkin (DG) Method for Nonlinear Variational Wave Equation in the context of Nematic Liquid Crystal is described. The energy stability for the method will be established and numerical illustrations will be provided to validate the accuracy and capability of the method.

Bernd Krauskopf is a Professor of Applied Mathematics at The University of Auckland. He received an MSc from RWTH Aachen and then a PhD from the University of Groningen. He held temporary positions at Cornell University and Amsterdam before joining the University of Bristol in 1998, where he worked until joining The University of Auckland in 2011. Professor Krauskopf's research is in dynamical systems theory and its applications, and he has published over 200 academic journal papers. He made fundamental contributions to theory and led impactful research programmes that introduced new techniques to solve real-world problems, including determining the observable dynamics of prototypical laser systems, analysing and improving aircraft ground manoeuvring, and understanding feedback mechanisms in control and climate modelling. Prof. Krauskopf has been PI on large grants, including an Advanced Research Fellowship, the Dodd-Walls Centre of Research Excellence and a Marsden grant, and received substantial industry funding.

Prof. Bernd Krauskopf

University of Auckland
New Zealand

Taking an aircraft for a spin on the ground

Aircraft are designed to fly but also need to operate efficiently and safely as vehicles on the ground. The tricycle configuration of commercial aircraft presents challenges for manoeuvres, such as high-speed turns off a runway. The bifurcation analysis of an industry-validated model shows that the sudden loss of lateral stability of a mid-size passenger aircraft turning on the ground is due to what is known as a canard phenomenon, which arises from a non-obvious splitting of the system into slow and fast variables. We present a canonical two-dimensional slow-fast vector field model that captures the key feature of a slow manifold with an asymptote. Physically, the canard phenomenon represents the saturation in quick succession of the lateral holding forces at both main landing gears. This is joint work with Etienne Coetzee (Airbus), Mathieu Desroches (INRIA), James Rankin (University of Exeter) and Mark Lowenberg (University of Bristol).

With a background in physics/biophysics, mathematical modelling and computational biology, research programs in the laboratory of **Dr. Ganusov** are diverse and include quantitative understanding of mechanisms driving immune responses to infections. One focus of current research is on understanding how Plasmodium sporozoites, a causative agent of malaria, establish infection in a new host, and how vaccine-induced immunity such as sporozoite-specific antibodies and CD8 T cells interfere with the infection process. In collaboration with various experimental groups, Dr. Ganusov's group is building mathematical models of the infection process and immune response and parameterizes these models using data from intravital microscopy experiments. Another focus of the research is on how Mycobacterium tuberculosis establishes the infection and disseminates in the lung and to extrapulmonary sites. Dissemination of bacteria is tracked using an ultra-low dose infection of mice and the use of barcoded strains of Mtb. Other areas of interest include mathematical modelling of T lymphocyte recirculation in the whole body, regulation of bacterial cell division, virus cooperativity at infection of cells and when spreading in plants. Dr. Ganusov's research is supported primarily by the NIH.

Prof. Vitaly V. Ganusov

Texas Biomedical Research Institute
USA

Mathematical modelling to guide experimental design: T cell clustering as a case study

Mathematical modelling provides a rigorous way to quantify immunological processes and to discriminate between alternative mechanisms driving specific biological phenomena. Mathematical models of immunological phenomena often are developed by modellers to explain specific sets of experimental data after the data have been collected by experimental collaborators. Whether the available data are sufficient to accurately estimate model parameters or to discriminate between alternative models is not typically investigated. Here I show how one can use mathematical modeling to define the type and size of experimental data needed to accurately estimate model parameters (a.k.a., power analysis). I will use a case study of the kinetics of formation of clusters of T lymphocytes around malaria parasite-infected hepatocytes observed in livers of mice with microscopy. I illustrate how following the dynamics of T lymphocyte clusters around individual parasitized cells allows for more accurately estimated model parameters; however, such experiments typically have a higher cost. Combining experimental design with mathematical modeling-driven power analyses should help design more effective experiments.

Dr. Premadasa is a virologist with over a decade of experience in infectious disease research, particularly focusing on HIV pathogenic and therapeutic research using non-human primate animal models. As a staff scientist at Texas Biomed at Mohan lab, she is studying the impact of HIV infection and antiretroviral therapy (ART) and particularly, the effect of long-term low-dose phyto-cannabinoids as an adjunct to antiretroviral therapy on HIV-associated co-morbidities such as neuro-cognitive disease, gastro-intestinal disorders. Currently, she is primarily researching on systemic inflammation-driven HIV-associated cardiovascular disease and liver diseases such as Non-alcoholic fatty liver disease and Cholestasis, funded through Texas Biomed forum grant.

Dr. Lakmini Premadasa

Texas Biomedical Research Institute
USA

Advancing the Fight Against Dengue: Exploring Vector Competence, Vaccine Development, and Antiviral Strategies

Dengue, a viral disease transmitted by Aedes mosquitoes, is predominant in tropical and subtropical climates. The causative agent, dengue virus (DENV), belongs to the Flaviviridae family and encompasses four distinct serotypes (DENV-1 to DENV-4). Infection can lead to a spectrum of clinical manifestations, ranging from asymptomatic to severe dengue hemorrhagic fever and dengue shock syndrome. DENV manipulates host immune responses, evading initial detection and later inducing immunopathological effects. Management is primarily supportive, as no specific antiviral treatment exists. Prevention relies on vector control and the partially effective dengue vaccine, Dengvaxia. In this talk, we will briefly discuss the ongoing research aims to develop more effective vaccines and antiviral therapies, as well as the importance of understanding vector competence.

Dr. Jordi B. Torrelles is a Professor in the Population Health Program, the Founding Director of the International Center for the Advancement of Research & amp; Education (I●CARE), the Director of the ABSL3/BSL3 Operations Program, and the co-director of the Biocontainment & Biosafety Core of the NIH-funded Interdisciplinary NexGen TB research Advancement Center (IN-TRAC). He has a broad background in tuberculosis (TB) biochemistry, immunology, cell biology, animal models, diagnostics, and therapeutics. The focus of Torrelles laboratory research program is studying of components of the human lung mucosa, in particular alveolar lining fluid components, in determining the interaction of respiratory microbes with host cells in vitro, ex vivo and invivo, and their impact on the establishment and outcome of the infection. Dr. Torrelles is also involved in improving the current TB vaccine, called BCG, for both, to prevent the development of active TB disease as well as a therapy for bladder cancer. Finally, Dr. Torrelles is involved in the development of a novel agar-based phenotypic drug susceptibility testing (DST) for drug-resistant TB specially designed for rural areas in low and middle-income countries.

Prof. Jordi B. Torrelles

Texas Biomedical Research Institute
USA

Early stages of Mycobacterium tuberculosis infection dynamics.

Tuberculosis (TB) is a disease that still kills one person every 21 seconds. Besides the dedicated efforts in the TB field in developing new therapies and vaccines, the emerging of drug resistance M. tuberculosis strains together with comorbidities such as HIV co-infection, diabetes, and ageing, is complicating the scenario for the control and eradication of this disease. M. tuberculosis has evolved changing its cell envelope composition to bypass the mechanisms of killing of the host cells hijacking the human immune response to its own benefit. In this talk, we will highlight the current efforts to understand the early events of M. tuberculosis infection, as well as current efforts on diagnostic, vaccines, and therapies against TB.

Dr. Pushpi Paranamana is an Assistant Professor in the Department of Mathematics & Computer Science at Saint Mary's College, Notre Dame, USA. She is an applied mathematician with research interests in mathematical modeling, analysis and simulations of physical and human systems using tools in differential equations, numerical analysis, Markov chain theory, data science and machine learning. Previously she was a visiting assistant professor at University of Notre Dame and a Postdoctoral Researcher at Rutgers University-Newark. Pushpi received her PhD in Mathematics from Texas Tech University, USA, and is an alum of the University of Colombo.

Dr. Pushpi Paranamana

Saint Mary's College
USA

Systems of linear ODEs and Stability

This is the first lecture of the minicourse; A Hitchhiker's Guide to Control Theory.
It is an introduction to linear systems of ordinary differential equations (ODEs), which provides a discussion on solutions for systems of linear ODEs, visualizing trajectories via phase plane and stability analysis. Some examples related to real world applications will be examined.

Dr. Kasun Fernando, currently a Lecturer in Mathematics at Brunel University London, engages in research at the intersection of Dynamical Systems, Probability Theory, and Statistics, along with some applications to Machine Learning. Previously, he was a Junior Visitor in Dynamical Systems at the Scuola Normale Superiore di Pisa in Italy, and a postdoctoral fellowship at the University of Toronto in Canada. Kasun earned his PhD in Mathematics from the University of Maryland in the United States, and is an alum of the University of Colombo.

Dr. Kasun Fernando

Brunel University London
UK

Lyapunov Stability Analysis

This is the second lecture of the minicourse; A Hitchhiker's Guide to Control Theory. It is an introduction to the Lyapunov's indirect and direct methods of stability analysis. The indirect method employs linearization to deduce the local stability properties around equilibrium points, while the direct method utilizes Lyapunov functions to evaluate both local and "global" stability. The lecture will also include a brief discussion about the implications of Lyapunov stability to Control Systems.

Dr. Buddhika Priyasad currently serves as a postdoctoral researcher at the University of Konstanz, Germany, with a primary focus on analysis, control theory, optimal control theory, and stabilization theory related to partial differential equations governed by fluid dynamical systems. Before his current position, he held postdoctoral positions at Charles University in Prague, Czechia, and the University of Graz, Austria. He earned his Ph.D. in Mathematics from the University of Memphis, USA, and completed his bachelor's degree at the University of Colombo.

Dr. Buddhika Priyasad

University of Konstanz
Germany

Linear Control Theory

This presentation constitutes the third session of the mini course titled "Hitchhiker's Guide to Control Theory." During this session, our primary emphasis is on exploring fundamental concepts within finite-dimensional control theory. Specifically, we delve into crucial topics such as controllability, stabilizability, feedback controls, and optimal controls.

Dr. Muhammad Fakhruddin completed his undergraduate education (BSc 2015) at the Department of Mathematics, Brawijaya University. He then continued his postgraduate program with a PMDSU scholarship (MSc 2017, Ph.D. 2020) at the Department of Mathematics, Bandung Institute of Technology. He was a lecturer in the Department of Mathematics, the Republic of Indonesia Defense University from 2020 to 2022. He was a lecturer in Mathematics and Statistics Department, Bina Nusantara University in 2023. His research interests are mathematical modeling, optimization, dynamical system, biomathematics, and the application of mathematics in defense.

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Dr. Muhammad Fakhruddin

Bina Nusantara University
Indonesia

Unveiling the Dynamics of Infectious Diseases through Mathematical Modeling and Parameter Estimation

In this mini workshop, we will dive into the dynamics of infectious diseases for undergraduate students. We will explore the basics of modeling infectious diseases, providing a clear introduction, assumptions, and terminology to infectious diseases. Students will gain valuable insights and a strong foundation to grasp how infectious diseases work, from explaining essential concepts of modeling to making sense of estimating parameters.

Maia Martcheva is a professor of mathematics at University of Florida. She obtained her PhD at Purdue University in 1998. After that she was a postdoc at the Institute for Mathematics and its Applications, University of Minnesota, Arizona State University and an NSF Advance Fellow at Cornell University in 2002-2003. Since 2003 she has been an Assistant, Associate and Full Professor at the Department of Mathematics, University of Florida. Maia Martcheva has published over 140 articles. Maia Martcheva has also published 3 books: Gender Structured Population Modeling (2005, SIAM), An Introduction to Mathematical Epidemiology (2015, Springer), and Age Structured Population Modeling (2020, Springer). Her research has been supported by the National Science Foundation. In 2016-2018 Maia Martcheva was a Managing Editor of Journal of Biological Systems. Currently, she serves on the editorial boards of Journal of Biological Systems, Journal of Biological Dynamics and Journal of Difference Equations with Applications.

Prof. Maia Martcheva

University of Florida
USA

Introduction to Mathematical Epidemiology and a Case Study on Modeling HIV and Opioid Epidemics

This talk involves two parts. Part I is a basic introduction to Mathematical Epidemiology. I will introduce the Kermack-McKendtrick SIR model and I will discuss how more complex models can be developed from this basic model. Next I will show how epidemiological models are fitted to data and parameters are estimated. Further, I will discuss briefly how sensitivity and elasticity of an epidemiological quantity with respect to the parameters is evaluated, and the role of the most elastic parameters in a epidemiological models. Part II demonstrates how these tools come into a play in an mathematical epidemiology example. The example I consider is modeling the HIV and opioid epidemics. I introduce an ordinary differential equation model of the HIV and opioid epidemics. The HIV and opioid epidemics reproduction numbers are computed as well as the invasion numbers. We find a disease-free, two boundary equilibria and at least one interior equilibrium in which both HIV and opioid addiction are present. We fit the model to US data and estimate the reproduction numbers and invasion numbers. We further evaluate the elasticities of the invasion numbers with respect to the reproduction numbers and two other key parameters of the model. We find that the best control strategies are treating opioid addicted individuals and reducing the likelihood that an opioid addicted individuals get infected with HIV.

Dr. Sandun Dassanayake conducts research specializing in spatial analysis and decision sciences. With expertise in GIS, Remote Sensing, and Machine Learning, Dr Dassanayake collaborates on interdisciplinary research in sustainable urban planning, geohazard predictions, and optimized geo-environmental design. Some of his influential work includes papers on developing hazard predictions for wildlife-damaged earth dams, Urban Heat Islands, and Acid Mine Drainage remediation. Dr Dassanayake's research groups are committed to using advanced computational methods and nature-based solutions for adapting to climate change.

Dr. Sandun Dassanayake

University of Moratuwa
Sri Lanka

Epidemic Trend Mapping and Advanced Visualization Techniques using Python and GIS

Understanding and combating infectious diseases in public health requires a deep appreciation for the spatial dimensions of epidemics. An efficient epidemic management and control strategy is based on mapping and analyzing spatial trends. To this end, Geographic Information Systems (GIS) and advanced visualization techniques provide essential tools, offering a solid foundation for examining and understanding spatial data. This workshop explores GeoPandas and QGIS's capabilities in capturing and analyzing epidemic trends using spatial statistics. GeoPandas, an extension of pandas, excels in handling geospatial data, enabling advanced spatial operations and analysis. Incorporating QGIS, an open-source GIS software, this workshop provides a comprehensive set of tools for visualizing spatial trends and performing spatial statistical analyses. Moreover, the workshop discusses workflows such as assessing the number of infections within specific areas and the spatiotemporal fluctuations and identifies patterns of spatial clustering and distribution. Attendees will be able to recognize critical areas and hotspots where diseases are likely to spread, allowing for precise interventions. By examining actual epidemic data, participants will acquire hands-on knowledge in analyzing epidemic patterns, running simulations using models such as the Susceptible-Infectious-Recovered (SIR) model, and utilizing spatial analysis methods to comprehend the movement of diseases.