NATIONAL MATHEMATICS INITIATIVE

(NMI)

(August 2014 – July 2015)

International Conference on

"Stochastic Systems and Applications"

(September 08 - 11, 2014)

DEPARTMENT OF MATHEMATICS

INDIAN INSTITUTE OF SCIENCE

BANGALORE

International Conference on
"Stochastic Systems and Applications"
(September 08 - 11, 2014)

ORGANIZING COMMITTEE

- Gopal K. Basak, Indian Statistical Institute, Kolkata
- Shalabh Bhatnagar, Indian Institute of Science, Bangalore
- Mrinal Kanti Ghosh, Indian Institute of Science, Bangalore (Convener)
- K. Suresh Kumar, Indian Institute of Technology Bombay, Mumbai
- S. Ramasubramanian, Indian Statistical Institute, Bangalore

ACKNOWLEDGEMENTS

The organizers wish to thank the **Science and Engineering Research Board (SERB)** for providing funding for this event and **Indian Institute of Science, Bangalore** for providing various facilities and organizational support for conducting the event.

Programme Schedule

NATIONAL MATHEMATICS INITIATIVE (NMI)
Indian Institute of Science, Bangalore

Conference on
STOCHASTIC SYSTEMS AND APPLICATIONS
(September 08 - 11, 2014)
Venue: LH-I, Department of Mathematics, IISc, Bangalore

Programme Schedule

September 08, 2014
(Monday)

09:00AM - 09:30 AM ***REGISTRATION***

Session 01 ***Chair: G. Rangarajan***

09:30 AM - 10:15 AM Some Random Distorted Gossip
Vivek S Borkar

10:15 AM - 11:00 AM A Hybrid Particle-Kalman Filter Method for High Dimensional Data Assimilation Problems
Amit Apte

11:00 AM - 11:30 AM **Tea/Coffee**

Session 02 ***Chair: N. Viswanadham***

11:30 AM - 12:15 PM Adaptive Policies for Online Ad Selection Under Chunked Reward Pricing Model
Dinesh Garg

12:15 PM - 01:00 PM Multiscale Q-learning with Function Approximation and an Application in Wireless Sensor Networks
Shalabh Bhatnagar

01:00 PM - 02:00 PM **Lunch**

Session 03 ***Chair: K. Suresh Kumar***

02:00 PM - 02:45 PM Gaussian Approximations in High Dimensional Estimations
Neeraja Sahasrabudhe

02:45 PM - 03:30 PM On a New Class of Ergodic Control Problems Arising from the Multi-Class Queuing Systems
Anup Biswas

03:30 PM - 04:00 PM **Tea/Coffee**

Session 04 ***Chair: Shalabh Bhatnagar***

04:00 PM - 04:45 PM A Dynamic Model of Capital Inflow in an Infinite Horizon Framework
Gopal K. Basak

NATIONAL MATHEMATICS INITIATIVE (NMI)
Indian Institute of Science, Bangalore

Conference on
STOCHASTIC SYSTEMS AND APPLICATIONS
(September 08 - 11, 2014)
Venue: LH-I, Department of Mathematics, IISc, Bangalore

Programme Schedule

September 09, 2014
(Tuesday)

Session 05 ***Chair: Gopal K. Basak***

09:30 AM - 10:15 AM — A Pollaczek-Khinchine Formula for Multidimensional Ruin Problem
S. Ramasubramanian

10:15 AM - 11:00 AM — Some New Results on the Geometry of Random Fields
Sreekar Vadlamani

11:00 AM - 11:30 AM — **Tea/Coffee**

Session 06 ***Chair: Sandeep Juneja***

11:30 AM - 12:15 PM — Green Supply Chain Design: An Ecosystem Approach
N. Viswanadham

12:15 PM - 01:00 PM — Revenue Maximisation with Tatkal Seva
D. Manjunath

01:00 PM - 02:00 PM — **Lunch**

Session 07 ***Chair: Vinod Sharma***

02:00 PM - 02:45 PM — Visual Search as Active Sequential Hypothesis Testing
Rajesh Sundaresan

02:45 PM - 03:30 PM — On Competitive Provisioning of Cloud Services
Jayakrishnan Nair

03:30 PM - 04:00 PM — **Tea/Coffee**

Session 08 ***Chair: Rajesh Sundaresan***

04:00 PM - 04:45 PM — Gap Probabilities in Certain Point Processes
Manjunath Krishnapur

NATIONAL MATHEMATICS INITIATIVE (NMI)
Indian Institute of Science, Bangalore

Conference on
STOCHASTIC SYSTEMS AND APPLICATIONS
(September 08 - 11, 2014)
Venue: LH-I, Department of Mathematics, IISc, Bangalore

Programme Schedule

September 10, 2014
(Wednesday)

Session 09 ***Chair: D. Manjunath***

09:30 AM - 10:15 AM — Ordinal Optimization in Simulation and Pure Exploration Multi-Armed Bandit Methods
Sandeep Juneja

10:15 AM - 11:00 AM — A Multi-Armed-Bandit Crowdsourcing Mechanism with Incentive Compatible Learning
Y. Narahari

11:00 AM - 11:30 AM — **Tea/Coffee**

Session 10 ***Chair: Arup Bose***

11:30 AM - 12:15 PM — Dense Graph Limits Under Respondent-Driven Sampling
Siva Athreya

12:15 PM - 01:00 PM — Probabilistic Juggling
Arvind Ayyer

01:00 PM - 02:00 PM — **Lunch**

Session 11 ***Chair: S. Ramasubramanian***

02:00 PM - 02:45 PM — Limiting Spectral Distribution of Symmetrized Autocovariance Matrices for Infinite Dimensional Vector Linear Process
Arup Bose

02:45 PM - 03:30 PM — **Tea/Coffee**

Session 12 ***Chair: Rahul Roy***

03:30 PM - 05:00 PM — FELICITATION

NATIONAL MATHEMATICS INITIATIVE (NMI)
Indian Institute of Science, Bangalore

Conference on
STOCHASTIC SYSTEMS AND APPLICATIONS
(September 08 - 11, 2014)
Venue: LH-I, Department of Mathematics, IISc, Bangalore

Programme Schedule

September 11, 2014
(Thursday)

Session 13	***Chair: Srikanth K. Iyer***
09:30 AM - 10:15 AM	Novel Algorithms for Distributed Detection *Vinod Sharma*
10:15 AM - 11:00 AM	A Non linear Donsker-Varadhan Variational Formula and Risk-sensitive Control *K. Suresh Kumar*
11:00 AM - 11:30 AM	**Tea/Coffee**
Session 14	***Chair: Manjunath Krishnapur***
11:30 AM - 12:15 PM	The Monotonicity Inequality and Uniqueness of SPDE's *B. Rajeev*
12:15 PM - 01:00 PM	Autoregressive Cascades on Random Networks *Srikanth K. Iyer*
01:00 PM - 02:00 PM	**Lunch**
Session 15	***Chair: M. K.Ghosh***
02:00 PM - 02:45 PM	Marginalization for Rare Event Simulation in Switching Diffusion *Anindya Goswami*
02:45 PM - 03:30 PM	Ergodic Control of Nonexpansive and Degenerate Diffusions *K. Mallikarjuna Rao*
03:30 PM - 04:00 PM	**Tea/Coffee**

Titles & Abstracts

A hybrid particle-Kalman Filter Method for High-Dimensional Data Assimilation Problems

Amit Apte
International Centre for Theoretical Sciences, Bangalore

Particle filtering is a powerful method for nonlinear filtering problems but it works well in systems with small dimensions because they suffer from the "curse of dimensionality," i.e. the computational effort required grows exponentially with dimensional of the system. Kalman filters, on the other hand, are successful in dealing with large dimensional problems which are close to being linear. The data assimilation in earth sciences is essentially a filtering problem for high dimensional and highly nonlinear system, so the use of either particle or Kalman filters leads to different types of difficulties as noted above.

After giving a general introduction to this problem, I will describe a proposal for a hydrid particle-Kalman filter method, specifically in the context of Lagrangian data assimilation. I will present promising results about the efficacy of this proposed method and discuss its shortcomings.

Based on joint with Laura Slivinski, Elaine Spiller, and Bjorn Sandsted

Dense Graph Limits Under Respondent-Driven Sampling

Siva Athreya
Indian Statistical Institute Bangalore, Bangalore

We consider certain respondent-driven sampling procedures on dense graphs. We show that if the sequence of the vertex-sets is ergodic then the limiting graph can be expressed in terms of the original dense graph via a transformation related to the invariant measure of the ergodic sequence. For specific sampling procedures we describe the transformation explicitly.

This is joint work with Adrian Rollin.

Probabilistic Juggling

Arvind Ayyer
Indian Institute of Science, Bangalore

We consider a juggler who has k balls, can throw up to maximum height h and throws each successive ball to a random height subject to the condition that no two balls arrive at the same time. Such Markov chains and their variants were first considered by Warrington in 2005, who found the stationary distribution when the heights were chosen uniformly. We generalize his results in several directions with arbitrary height probabilities. Lastly, we show that one particular Markov chain converges to its stationary distribution in finite time.
This is joint work with Jeremie Bouttier, Sylvie Corteel and Francois Nunzi.

A Dynamic Model of Capital Inflow in an Infinite Horizon Framework

Gopal K. Basak
Indian Statistical Institute Kolkata, Kolkata

We model capital inflow in mean-variance structure of portfolio choice in infinite time horizon. Starting with capital inflow in a two country framework in infinite time horizon we extend the model to the case of several borrowing countries. A capital scarce country, typically a developing country with a high return on capital borrows from a capital-rich country, typically a developed country to finance domestic investment. The former has lower saving than its investment demand while it is just the other way round in the developed country. In the process both the countries gain, raising the world welfare. We formulate the problem in a mean-variance framework for choice of optimal portfolio of borrowing and lending for both the develop and developing countries perspective over infinite time horizon. Using dynamic programming principle a la Bellman we numerically solve for inter temporal equilibrium paths of interest rate, quantum of borrowing (and lending) and exchange rate. We further extend this model for the case of one lending country (or country group that can be interpreted as the developed world) and several borrowing (or developing) countries. Besides solving for inter temporal equilibrium of interest rate, quantum of borrowing (and lending) and their exchange rates we explore the contagion effect where crisis of one country in the borrowing group may inflict on others and the possibility of financial crisis.

(The work is jointly done with Pranab Kumar Das and Allena Rohit)

Multiscale Q-learning with Function Approximation and an Application in Wireless Sensor Networks

Shalabh Bhatnagar
Indian Institute of Science, Bangalore

Q-learning is one of the most widely used algorithms in reinforcement learning. However, when combined with function approximation (a commonly used technique to handle the curse of dimensionality), it is known to diverge in some cases. Further, there is no proof of convergence of this algorithm when combined with function approximation.

We present a multiscale variant of Q-learning with function approximation where the Q-value updates are performed on a faster timescale while the policy updates are conducted on a slower timescale. We show the convergence of the algorithm. Next, we study an application of our algorithm in the problem of finding optimal sleep-wake schedules for sensors placed in a certain region with the aim of detecting intruder movement. We observe good performance when using our proposed algorithm.

On a New Class of Ergodic Control Problems Arising from the Multi-Class Queuing Systems

Anup Biswas
University of Texas at Austin, USA

In this talk I plan to propose some control problems for multi-class many server queuing model and the known/unknown results related to it. One of the main goals is to find a scheduling policy that is asymptotically optimal in certain sense. It is not always easy to find a simple policy which is optimal. We will also see some examples when one can obtain simple optimal policies. A major part of the talk will be devoted to the long time average cost. We will see that the associated ergodic control problem is different from those studied in literature. We propose some new methods to analyze these kind of ergodic control problems.
Part of the talk is based on a joint work with Ari Arapostathis and Guodong Pang.

Some Random Distorted Gossip

Vivek S. Borkar
Indian Institute of Technology Bombay, Mumbai

Gossip has always been a thrust area on academic campuses. Taking advantage of my greying hair and aging brain cells, I shall indulge in that favourite pastime of academic dotards - some random, distorted gossip. To add a veneer of culture (of sorts), I shall draw occasional parallels with thoughts expressed by some leading poet-philosophers of the last century.

Limiting Spectral Distribution of Symmetrized Autocovariance Matrices for Infinite Dimensional Vector Linear Process

Arup Bose
Indian Statistical Institute Kolkata, Kolkata

We consider the sequence of autocovariance matrices for Infinite Dimensional Vector Linear Process. We consider two symmetrized version of these matrices -- the symmetric sum and the symmetric product and show that the Limiting Spectral Distribution exists in each case. We provide the moment formulae of these limits in terms of moments of some freely independent variables. Explicit description of the limit is given in some special cases. This work is joint with Octavio Arizmendi and Monika Bhattacharjee.

Adaptive Policies for Online Ad Selection Under Chunked Reward Pricing Model*

Dinesh Garg
IBM, Bangalore

As the online advertising market is maturing, advertisers are becoming increasingly demanding and online ad agencies/publishers are being forced to innovate newer pricing models to stay competitive in the marketplace and attract more advertisers towards their portals. In recent times, Group Inc. has demonstrated the phenomenal success of a new pricing model, namely "chunked reward" pricing model. In this model, an advertiser pays to the publisher only upon receiving a pre-determined reward in the form of either clicks or conversions. Such a payout model is more desirable for the advertisers because they can track their ROI on marketing spend in a much better way. While desirable for the advertiser, this pricing model presents significant algorithmic challenges for the publisher or the ad agency in terms of deciding which ads to show to an online user. In this talk, we show that the ad selection problem under chunked reward pricing model proves to be a variant of the stochastic knapsack problem and, therefore, it is computationally hard. Further, we investigate how revenue for the publisher may be optimized under this model. We give theoretical guarantees for many adaptive greedy policies for this problem. Using extensive experiments, we compare a number of ad selection policies and demonstrate their strengths and weaknesses. Our experimental results demonstrate that many adaptive greedy policies are much closer to optimal than what the theoretical bounds suggest.

*Acknowledgement: This is a joint work with Michael Grabchak (UNC, Charlotte), Narayan Bhamidipati (Yahoo!), and Rushi Bhatt (Amazon).

Marginalization for Rare Event Simulation in Switching Diffusion

Anindya Goswami
Indian Institute of Science Education and Research Pune, Pune

In this paper we use splitting technique to estimate the probability of hitting a rare but critical set by the continuous component of a switching diffusion. Instead of following classical approach, we use Wonham filter to achieve multiple goals including reduction of asymptotic variance and exemption from sampling the discrete components.

Autoregressive Cascades on Random Networks

Srikanth K. Iyer
Indian Institute of Science, Bangalore

Consider any infinite locally finite, tree-like graph. Each node bears a random load and a random capacity. Initially all nodes are assumed to have loads smaller than their capacities, except at one node where the load exceeds its capacity. This node is then said to have faileed. The load at any failed node is distributed according to a random partition to its non-failed neighbors at the next time instant. We provide sufficient conditons for the cascade to survive indefinitely with positive probability or to die out with probability one.

Ordinal Optimization in Simulation and Pure Exploration Multi-Armed Bandit Methods

Sandeep Juneja
Tata Institute of Fundamental Research Mumbai, Mumbai

Consider the ordinal optimization problem of finding a population amongst many with the largest mean when these means are unknown but population samples can be generated via simulation. Typically, by selecting a population with the largest sample mean, it can be shown that the false selection probability decays at an exponential rate. Lately researchers have sought algorithms that guarantee that this probability is restricted to a small δ in order $\log (1/\delta)$ computational time by estimating the associated large deviations rate function via simulation. We show that such guarantees are misleading. We then adapt methods from multi-armed bandit literature to devise algorithms that provide these computational guarantees on the probability of false selection.

(jointly with Peter Glynn, Stanford University)

Gap Probabilities in Certain Point Processes

Manjunath Krishnapur
Indian Instiute of Science, Bangalore

Let X be a point process (i.e., a random discrete set of points) in R^d. For any set A, let h(A) be the probability that there are no points of X in A. It is referred to as the gap probability or hole probability for the set A. For the simplest case of a unit intensity Poisson process, h(A)=\exp\{-vol(A)\}. In this lecture we consider certain determinantal point processes (that rise as eigenvalues of a random matrix) and calculate their hole probabilities up to a constant factor in the exponent. This is joint work with Kartick Adhikari.

A Non linear Donsker-Varadhan Variational Formula and Risk-sensitive Control

K. Suresh Kumar
Indian Institute of Technology Bombay, Mumbai

In this talk we present a new method to study risk-sensitive control problems. It is based on a generalization of Donsker-Varadhan variational formula. This is a joint work with A. Arapostathis and V.S. Borkar.

Revenue Maximisation with Tatkal Seva

D. Manjunath
Indian Institute of Technology Bombay, Mumbai

A server will serve N customers from a FIFO queue starting at time 0; all arrivals are before 0. Cost to a customer is weighted sum of waiting time before 0 and sequence number of service; these have different weights for different customers. We first analyse the equilibirium arrival process when each customer chooses its arrival time selfishly. We then consider the case when server has K queues and charges c_k for taking service from queue $k,$ a la tatkal seva; queue k has strict priority over queue $k+1.$ Now customers have three cost components---$c_k,$ waiting time and service sequence. We analyse the equilibrium arrival process and server revenue when customers choose arrival time and queue selfishly. Increasing K increases revenue but we see that revenue is nearly maximised for about $K=4.$

Joint work with Rajat Talak and Alexandre Proutiere.

On Competitive Provisioning of Cloud Services

Jayakrishnan Nair
Indian Institute of Technology Bombay, Mumbai

Motivated by cloud services, we consider the interplay of network-effects, congestion, and competition in ad-supported services. We study the strategic interactions between competing service providers and a user base, modeling congestion sensitivity and two forms of positive network-effects: ``firm-specific'' versus ``industry-wide.'' Our analysis reveals that users are generally no better off due to the competition in a marketplace of ad-supported services. Further, our analysis highlights an important contrast between firm-specific and industry-wide network-effects: firms can coexist in a marketplace with industry-wide network-effects, but near-monopolies tend to emerge in marketplaces with firm-specific network-effects.

A Multi-Armed-Bandit Crowdsourcing Mechanism with Incentive Compatible Learning

Y. Narahari
Indian Institute of Science, Bangalore

Consider a requester who wishes to crowdsource a series of identical tasks from a pool of workers so as to achieve an assured accuracy for each task, in a cost optimal way. The workers are heterogeneous with unknown but ﬁxed qualities and moreover their costs are private. The problem is to select an optimal subset of the workers to work on each task so that the outcome obtained from aggregating labels from them guarantees a target accuracy. This problem typical of current crowdsourcing platforms and is interesting because the requester not only has to learn the qualities of the workers but also elicit their true costs. We develop a novel multi-armed bandit (MAB) mechanism for solving this problem. In particular, we propose a framework, Assured Accuracy Bandit (AAB), which leads to an adaptive, exploration separated MAB algorithm, Strategic Constrained Conﬁdence Bound (CCB-S). We derive an upper bound on the number of exploration steps which depends on the target accuracy and true qualities. We show that our CCB-S algorithm produces an ex-post monotone allocation rule which can be transformed into an ex-post incentive compatible and ex-post individually rational mechanism that learns qualities of the workers and guarantees the target accuracy in a cost optimal way.

(Joint work with Shweta Jain, Sujit Gujar, Satyanath Bhat, Onno Zoeter)

The Monotonicity Inequality and Uniqueness of SPDE's

B. Rajeev
Indian Statistical Institute Bangalore, Bangalore

The Monotonicity inequality (along with the Gronwall inequality) is a useful tool to prove uniqueness for a class of SPDE's. The original proof was given in Mandrekar, Gawarecki & Rajeev(2009). In this talk we will describe a new proof by Rajeev Bhar (2013), based on an analysis of the derivative operator acting on Hermite-Sobolev spaces.

A Pollaczek-Khinchine formula for multidimensional ruin problem

S. Ramasubramanian
Indian Statistical Institute Bangalore, Bangalore

We consider multidimensional insurance models described in terms of Skorokhod problem in an orthant. A natural notion of ruin is defined. This leads to an appropriate notion of multidimensional ladder height distribution. A Pollaczek-Khinchine formula for ruin probability is presented.

Ergodic Control of Nonexpansive and Degenerate Diffusions

K. Mallikarjuna Rao
Indian Institute of Technology Bombay, Mumbai

We consider the ergodic control of non expansive and degenerate diffusions. We show the existence of value and characterise this by a system of coupled HJB equation.

Gaussian Approximations in High Dimensional Estimations

Neeraja Sahasrabudhe
Indian Institute of Technology Bombay, Mumbai

Several estimation techniques, such as EnKF, assume that the underlying probability distribution functions are Gaussian. Interestingly, these ensemble methods have proven to work very well for high-dimensional data even when the distributions involved are not necessarily Gaussian. We attempt to bridge the gap between this oft-used computational assumption and the theoretical understanding of why this works by employing some recent results on random projections on low dimensional subspaces, concentration inequalities, and a variant of the Johnson-Lindenstrauss Lemma.

Novel Algorithms for Distributed Detection

Vinod Sharma
Indian Institute of Science, Bangalore

Authors: F Ibrahim and Vinod Sharma

We present new algorithms for hypothesis testing when multiple nodes sense the data, make local decisions and transmit them to a fusion center. The fusion center makes the final decision based on the local decisions received by it on a noisy channel. Our algorithms are sequential and nonparametric. Pitman Asymptotic Relative Efficiency and asymptotic performance are computed. Finally these algorithms are compared with other algorithms available in literature.

Visual Search as Active Sequential Hypothesis Testing

Rajesh Sundaresan
Indian Institute of Science, Bangalore

I will describe a visual search experiment conducted by Sripati and Olson (2010) where the objective was to identify, as quickly as possible, an oddball image embedded among multiple distractor images. Remarkably, the reaction times for identifying the oddball (in humans) were highly correlated with an ad hoc neuronal metric obtained from measured neuronal responses to component images (in macaques). I will suggest an alternative neuronal metric that is based on an active sequential hypothesis testing model of visual search, and on a classical result of Chernoff on sequential design of experiments (1959). The correlation between the reaction times and the alternative neuronal metric continues to be high, and has the advantage of being firmly grounded in decision theory. I will then discuss some predictions made by our model, and additional experiments that highlight the challenges involved in the modeling. The talk is based on ongoing work with Nidhin Koshy Vaidhiyan and Arun Sripati.

Some New Results on the Geometry of Random Fields

Sreekar Vadlamani
Tata Institute of Fundamental Research Bangalore, Bangalore

We shall discuss some formulae related to some global geometric characteristics of excursion sets (or level sets) of specific random fields. In the process we shall also shed some new light on the approximations of suprema probability of Gaussian random fields using the mean Euler-Poincar\'{e} characteristic of its excursion sets.

Green Supply Chain Design: An Ecosystem Approach

N. Viswanadham
Indian Institute of Science, Bangalore

Behind every product or service there is a supply chain or service chain. The resources that are used to manufacture the product such as car, phone or a coke can and their carbon foot print or services such as transportation, energy, storage depends on the efficiency of the supply chain or service chain. Our efforts aim to design the supply chain so that the carbon foot print and the resources utilization are minimal and the products are designed to be recyclable. Thus design of green supply chain depends on the supply chain configuration, the resources, the institutional factors involving governments and social groups and finally the product delivery mechanisms and carbon trading opportunities.

In this lecture, we concentrate on the design of green supply chain networks (GSCN). Our GSCN map consist of forward-backward supply chains, natural, human and industrial resources, Governments and Social groups and delivery mechanisms. Our framework enables one to design the GSCN taking into account the possible innovations, mitigating possible risks and finally improving the performance of the forward as well as reverse chain. Finally we also focus on architectures for Governance, Coordination and Control GSCNs by splitting the task of governance in to three: selection of partner companies, determination of the most effective form of the relationship among the selected partner companies and finally monitoring and execution of the agreed delivery schedules. This is in contrast to the optimization procedures currently available to minimize the waste and carbon foot print.

The uniqueness of our approach lies in the fact that we can extend the same to design a green city or a green region by considering the city or region as a bundle of services. We then make connection with the climate change efforts in cities, countries, etc.