THIRUMULANATHAN D

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DOB/ Age : 19.12.1988/ 33
Nationality : Indian
Current affiliation: Assistant Professor Grade-I, Indian Institute of Technology, Kanpur.

TEACHING EXPERIENCE

AS FACULTY

I was the instructor for the following courses.

- Applied game theory (ECO502A) during 2020-21-I and 2021-22-I semesters.
- Introduction to mathematical economics (ECO261A) during 2020-21-II semester.
- Machine Learning for Economists (ECO765A) during 2021-22-II semester.

I was the tutor for the course "Applied probability and statistics" (HSO201A) during 2020-21-II and 2021-22-II semesters.

AS PHD SCHOLAR

I was the teaching assistant (TA) for the following three courses during my Ph.D. at IISc, Bengaluru.

- I was the TA for Data Analytics (E0-259) twice, in Aug-Dec 2015 and Aug-Dec 2016.
- I was the TA for Game Theory (E1-254) twice, in Jan-Apr 2015 and Jan-Apr 2016.
- I was the TA for Online Prediction and Learning (E1-245) in Aug-Dec 2014.

RESEARCH EXPERIENCE

My research has primarily been based on game theory, optimization, mathematical economics, data analytics, and wireless communication.

CURRENT WORK

1. **Machine learning based implementation of modules in communication systems:** Working with Samsung on implementing (i) decoder/ LLR/ network slicing modules, and (ii) rate-splitting based power allocation in communication systems.
2. **Optimal transport with quadratic costs:** Working with Prof. Joydeep dutta on writing a survey paper on this topic.
3. **Optimal mechanisms with correlated private values:** Working on computing a necessary condition to have a lower bound on the ratio of the revenue of lookahead auction and the social welfare for arbitrary distributions.
4. **Optimal auctions for multi-item multi-player setting:** Working on extending my earlier results (during PhD) on optimal auction mechanism in a multi-item setting to a multi-player setting.

PAST WORK

1. **Optimal Multi-dimensional Mechanisms:** Consider the problem of designing a revenue-optimal mechanism for selling two heterogeneous items to a single buyer. The general solution of this problem remains unsolved for over three-and-a-half decades. In our work, we solve the problem when the buyer's valuation for the items is uniformly distributed over an arbitrarily rectangle. We solve this problem in two different settings: (i) when the buyer has no demand constraint, and (ii)

when the buyer has a unit-demand constraint. The works are a part of my PhD thesis.

2. **Resource Allocation in the Presence of Strategic Users:** Consider the problem of designing a mechanism that satisfies incentive compatibility, allocative efficiency, and budget balance, to allocate a divisible good. But by Green-Laffont theorem, no mechanism satisfies all three properties simultaneously. We thus relax the budget balance constraint to near budget balance, i.e., minimize the surplus that is available with the designer of the mechanism. We model this problem as an optimization problem with a continuum of constraints and propose a solution method via constraint sampling. We also identify the number of samples sufficient for a good approximation. The specific contribution from this work is the design of an algorithm to compute an approximate solution for an optimization problem involving a continuum of constraints. The work is a part of my M.E. thesis.

ACADEMIC EXPERIENCE

- **Ph.D, Dept. of ECE & Dept. of CSA (joint), Indian Institute of Science, Bengaluru,** 2012-'17
  - Thesis Title: Optimal Mechanisms for Selling Two Heterogeneous Items
  - CGPA: 7.0/8.0
  - Courses: Topics in Game Theory, Design and Analysis of Algorithms, Linear Algebra, Measure Theory, Calculus on Manifolds, Ordinary Differential Equations.
- **M.E, Telecommunications, Dept. of ECE, Indian Institute of Science, Bengaluru,** 2010-'12
  - Thesis Title: Resource Allocation in the Presence of Strategic Users with Near Budget Balance.
  - CGPA: 6.7/8.0, with 'S' Grade in Project. Passed with *Distinction*.
  - Courses: Game Theory, Computational Methods of Optimization, Statistical Learning Theory, Random Processes, Error Control Codes, Information Theory, Wireless Communications, Wireless Networks, Detection and Estimation Theory.
  - Project: Multi-Armed Bandit Mechanisms for Sponsored Search Auctions, in the course Game Theory.
- **B.E, Dept. of ECE, College of Engineering Guindy, Chennai,** 2006-'10
  - Thesis Title: Outage Capacity Comparison Between STBC and V-BLAST in Wideband OFDM-MIMO Systems.
  - CGPA: 9.49/10.00
  - Courses: Signals and Systems, Control Systems, Digital Communication, Operating Systems, Digital Signal Processing, Programming and Data Structures.
  - Rank: 59 in Graduate Aptitude Test in Engineering (GATE), ECE stream.
- **Higher Secondary School, Satchidananda Jothi Niketan, Matric Hr. Sec. School, Kallar, Mettuppalayam,** 2004-'06
  - Marks: 1161/1200 (96.75%)
  - Rank: 2, in Tirupur educational district.
  - Rank: 72, in TamilNadu Professional Courses Entrance Examination (TNPCEE).

WORK EXPERIENCE

- **Indian Institute of Technology, Kanpur,** June 2020-present
  - Position: Assistant Professor Grade-I
- **Qualcomm India Pvt. Ltd.,** Apr 2017-May 2020
  - Position: Senior Engineer at modem systems team
  - Responsibilities: I was the point of contact for issues related to demodulator back end module, in UMTS. This was for a period of one year. Currently, I am the point of contact for Uplink related issues in LTE.
  - Projects completed: I worked on automating the process of detecting the failure point during modem testing. The process earlier was manual and thus used to take months. The

automation was proposed to reduce the man months required. The project involved coming up with a model to analyze the failure points, propose an algorithm to detect the point of failure, and implement it on field. I was chosen for this project based on my experience in data analytics.

- **Internship at Nokia Solutions and Networks India Pvt. Ltd.,** Feb-May 2016 (4 months)
  - Position: RRM Algorithm and Simulations Trainee
  - Projects completed: I implemented the NAICS (Network Assisted Interference Cancellation and Suppression) feature that was introduced in Release 10 of LTE.

PUBLICATIONS

Machine learning based implementation of modules in communication systems

1. Vankayala, S.K., Kumar, S., Shenoy, K.G., Thirumulanathan D, Yoon, S. and Kommineni, I., "**Neural Network Architecture for LLR Computation in 5G Systems and Related Business Aspects**". In Proceedings of 24th IEEE International Symposium on *Wireless Personal Multimedia Communications* (WPMC), 2021. Available online at https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9700456&casa_token=g66w3gK_YGoAAAAA:_laPqJBxLv0HNxb340rkBdULZnCK8Z0aqTotOPvWT1Rd-Pd0t5uri-AkwzRhYfV7kL4AsZ77eTs&tag=1
2. Vankayala, S.K., Kumar, S., Roy, I., Thirumulanathan D, Yoon, S. and Kanakaraj, S., "**Radio Map Estimation Using a Generative Adversarial Network and Related Business Aspects**". In Proceedings of 24th IEEE International Symposium on Wireless Personal Multimedia Communications (WPMC), 2021. (**Won the best paper award)**. Available online at https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9700474&casa_token=5-NCfdRWY2UAAAAA:9rknCUlsOR1m9UbjYssrvteGSELh77VuHovqTNpnsC8jbhodfMgoZrQNwAwLdBEwQBJmgXhnedo
3. Vankayala, S.K., Kumar, S., Thirumulanathan D, Yoon, S., Kommineni, I. and Lakshmi Narayana V.S. Ch., "**Sparse Dense Neural Network Architecture for Turbo Decoding in Cloud Systems**". In Proceedings of 2021 IEEE conference on *Advanced Networks and Telecommunication Systems* (ANTS): International Workshop on *5G and Future Wireless Technology*, 2021.
4. Vankayala, S.K., Kumar, S., Shah, V., Mathur, A., Thirumulanathan D, and Yoon, S., **"Reinforcement Learning Framework for Dynamic Power Transmission in Cloud RAN Systems"**. In proceedings of 2022 IEEE *Conference on Electronics, Computing and Communication Technologies* (CONECCT), 2022.
5. Vankayala, S.K., Kumar, S., Thirumulanathan D, Mathur, A., Yoon, S., and Kommineni, I., **"Deep-Learning Based Beam Selection Technique for 6G Millimeter Wave Communication"**. In Proceedings of 33rd IEEE International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC), 2022.

The works were done during my collaboration with Samsung Inc. as a faculty at IIT Kanpur.

Optimal multi-dimensional mechanisms

1. Thirumulanathan D, R Sundaresan, Y Narahari, "Optimal Mechanisms for Selling Two-Items to a Single Buyer Having Uniformly Distributed Valuations", *Journal of Mathematical Economics*, vol. 82, 2019, pp. 1--30. Available online at https://www.sciencedirect.com/science/article/abs/pii/S0304406819300138
2. Thirumulanathan D, R Sundaresan, Y Narahari, "On Optimal Mechanisms in the Two-Item Single-Buyer Unit-Demand Setting", *Journal of Mathematical Economics*, vol. 82, 2019, pp. 31—60. Available online at https://www.sciencedirect.com/science/article/abs/pii/S030440681930014X
3. Thirumulanathan D, R Sundaresan, Y Narahari, "Optimal Mechanisms for Selling Two-Items to a Single Buyer Having Uniformly Distributed Valuations", *In Proceedings of 12th Conference on Web and Internet Economics* (WINE), pages 174—187, 2016. Available online at https://link.springer.com/chapter/10.1007/978-3-662-54110-4_13

The works are a part of my Ph.D. thesis.

Resource allocation in the presence of strategic users

4. D Thirumulanathan, H Vinay, S Bhashyam, R Sundaresan, "Almost Budget Balanced Mechanisms With Scalar Bids For Allocation of a Divisible Good", *European Journal of Operational Research* (EJOR), vol. 262, pages 1196—1207, 2017. Available online at https://www.sciencedirect.com/science/article/abs/pii/S0377221717303648

This work is a part of my M.E. thesis.

EVENTS/ TALKS

- Gave a talk titled **"Use of PDFs and CDFs in Auction Theory"** during the QIP short term course on *Frontier Areas of International Trade and Econometrics*, March 2021, held online, and organized by the Indian Institute of Technology, Kanpur.
- Gave a talk titled **"Optimization theory and its applications to machine learning"** during the workshop on *Machine Learning and Applications*, February 2021, held online, sponsored by TEQIP-III, and organized by National Institute of Technology, Surathkal.
- Presented a poster titled **"On Optimal Mechanisms in the Two-Item Single-Buyer Unit-Demand Setting"** during the 13th Conference on Web and Internet Economics (WINE), December 2017, held at the Indian Institute of Science, Bengaluru.
- Presented a poster titled **"Almost Budget Balanced Mechanisms With Scalar Bids For Allocation of a Divisible Good"** during the 12th Conference on Web and Internet Economics (WINE), December 2016, held at Montreal, Canada.
- Gave a talk titled **"Optimal Mechanism for Selling Two Goods with Uniformly Distributed Valuations"** during the *Workshop on Static and Dynamic Mechanism Design*, August 2015, held at the Indian Statistical Institute, Delhi.
- Presented a poster titled **"Resource Allocation for Strategic Users Using Uncertain Convex Program"** at *IBM I-CARE 2012*, held at the Indian Institute of Science, Bengaluru.

AWARDS, PRIZES, PATENTS

TECHNICAL

- Awarded a *travel grant of $3,000* towards attending the WINE 2016 conference in Montreal, Canada, by Google Inc.

NON-TECHNICAL

- Was awarded the *Honorary Doctorate* in August 1995 by The World Academy of Arts and Culture, California, for reciting all 1330 couplets of Thirukkural at the young age of 4.
- Was awarded the *Kural Prize* by the Government of Tamilnadu in January 2000.
- Was felicitated in the Indian parliamentary campus in December 2015, for being the topper in the Thirukkural competition organized by Mr. Tarun Vijay, the then MP of Rajya Sabha. Was adjudged the first, among the 133 students selected for the felicitation.

ACHIEVEMENTS

- Can perform multi-tasking, involving up to 16 things at a time (*Shodasaavadhanam*).
- Won many prizes in Quiz competitions. Notably, have won the second prize in the regional finals of The Hindu Young World Quiz, 2005.

- My poems have appeared in leading Tamil magazines. Have delivered speeches regarding Thirukkural, Kamba Ramayanam, and various other literary works in Tamil.

(For more info, please refer to the website: www.sites.google.com/view/thirumulanathand)

ROLE IN EXTERNALLY FUNDED PROJECTS

AS FACULTY

- Obtained an initiation grant of Rs. 25,00,000/- from the institute on the project **"Optimal Auction Mechanisms for Selling Multiple Heterogeneous Items"**.

- Working on the project **"Rate Splitting for Multiple Access"**, sponsored by Samsung India, for a period of one year.

AS PHD SCHOLAR

- I worked on the project **"Dynamic Algorithms for resource allocation among multiple agents"**, sponsored by the Centre for Artificial Intelligence and Robotics, DRDO, during the period Nov 2014 - Oct 2018, with Prof. Rajesh Sundaresan as the PI. My Ph.D. thesis on designing optimal mechanisms for selling two heterogeneous items, and the papers that I have submitted to the Journal of Mathematical Economics (JME), were a part of this project.
- I worked on the project **"Network resource allocation in the presence of strategic users"**, sponsored jointly by the SERB and the DST, during the period Oct 2011 – Oct 2014, with Prof. Srikrishna Bhashyam and Prof. Rajesh Sundaresan as the Co-PI's. My M.E. thesis on designing an almost budget-balanced mechanism for allocating a divisible good, and my paper published at the European Journal of Operational Research (EJOR), were a part of this project.

TEXT BOOKS/ EDUCATION PROGRAMS

- **Text Book:** I worked on proof-reading the draft of the book **"Game Theory and Mechanism Design"** by Prof. Y Narahari. I provided some substantial inputs on various chapters of the book that helped improve its content. My work has been acknowledged in the preface of the book.
- **Education Program:** I was the teaching assistant for **Data Analytics (E0-259)** when it was first introduced by Prof. Rajesh Sundaresan and Prof. Ramesh Hariharan in Aug-Dec 2015. The course is novel in the sense that it involves giving a hands-on analysis of data sets from various fields like astronomy, neuroscience, sports, genomics, social networks, and the like, using statistical tools and models. I played a part in designing the assignment for each module along with the instructors. I also played a part in helping the students choose their course project.

SERVICE ROLES

AS FACULTY

- Travelled to Indore as an institute representative for JEE (Advanced) exam in September 2020 during covid-19 times. Travelled to Lucknow for the same reason in October 2021.
- Worked as an RTC (Remote Teaching Cell) representative of department of economics in 2020-21.
- Worked as a DPGC member in the department of economics in 2021-22.
- Was a part of the interview committee to select PhD students to the department for 2020-21-II and 2021-22-I semesters.

AS STUDENT

- I was the network administrator for our lab under Prof. Rajesh Sundaresan, during the period

2014-’15. My role involved maintaining the network system in the lab, ensuring the daily backups in the network, and troubleshooting for issues as and when they occur.

- I was also the contact point for maintaining the Sankhya network cluster, during the period 2014-’15. This was a network cluster available at the department of ECE at IISc, that enabled the students to submit time-consuming tasks in Matlab/ C & C++/ Qualnet. My key role was maintenance of the cluster and troubleshooting of the issues.
- I was a volunteer for the JTG summer school held at the Indian Institute of Science in 2013 and 2014. I designed and maintained the webpage for this event and was also a part of the registration for the outstation participants.
- I was also a student volunteer for the various conferences and workshops held at the Indian Institute of Science. Specifically, I volunteered for the following conferences/ workshop:
    - National Conference on Communications (NCC), 2011.
    - Conference on Signal Processing and Communications (SPCOM), 2012 & 2014.
    - NMI Workshop on Game Theory and Mechanism Design, Jan 2016.