P. N. Karthik

Personal Data

Date of Birth:	20 Apr 1992
Address:	06-12, Block E4, Engineering Drive 3, National University of Singapore, 117583
Phone:	+65 80432990
Email:	pnkarthik1992@gmail.com (personal), karthik@nus.edu.sg (official)
Website:	https://karthikpn.com
LinkedIn:	https://www.linkedin.com/in/pnkarthik/
Google Scholar:	https://scholar.google.com/citations?user=D39u7bkAAAAJ&hl=en&authuser=1

Research Interests

Multi-armed bandits, statistical learning, federated learning, transfer learning, information theory, sequential analysis, hypothesis testing, Markov decision processes, anomaly detection, stochastic adaptive control

Experience

Jan'22 - present **Research Fellow**
Institute of Data Science, National University of Singapore (NUS), Singapore
Supervisor: Prof. Vincent Y. F. Tan
- Characterising the performance limits of multi-armed bandit algorithms for federated learning, transfer learning, best arm identification, etc.
- Fostering collaborative ties between NUS and other prominent institutes such as IIT Madras (IITM), IIT Bombay (IITB), Rensselaer Polytechnic Institute (RPI)
- Assisting Ph.D. students and their supervisors at NUS and IITM, and contributing to the successful completion of Ph.D. research projects

Nov'19 - Mar'20 **Research Intern**
Netradyne Technology India Pvt. Ltd., Bengaluru (in collaboration with the Bengaluru Metropolitan Transport Corporation (BMTC))
- Studied the effectiveness of the bus priority lane (BPL) in Bengaluru based on travel times of public transport buses and driver stress levels
- Worked with large datasets (150 Gigabytes per month)
- Deployed Microsoft PowerBI and Kepler GL for geospatial data visualisation
- Proposed a novel technique for extracting travel times from GPS data
- Designed a novel metric for measuring driver stress
- Reported that the BPL reduced the worst 10% of the travel times by 4-28%
- Reported that the drivers were most stressed during the morning peak hours

Aug'19 - Dec'19
Aug'18 - Dec'18
Aug'17 - Dec'17 **Graduate Teaching Assistant**
Department of ECE, Indian Institute of Science, Bengaluru
Courses: Information Theory (E2 201), Random Processes (E2 202)
Instructors: Prof. Himanshu Tyagi, Prof. Utpal Mukherji, Prof. Parimal Parag
- Taught a class of 83 students (weekly, 1.5 hours per week)
- Evaluated students' answer scripts (weekly assignments)
- Assisted the instructors in formulating questions for exams & assignments

Aug'14 - Jun'15 **Project Assistant**
Department of ECE, Indian Institute of Science, Bengaluru
Supervisor: Prof. Chandra R. Murthy
- Characterised the area coverage uncertainty in a network of access points
- Validated the results with the data collected from access points at a hospital
- Presented the results to the Aerospace Network Research Consortium

Education

Jul'15 - Mar'22 **Doctor of Philosophy and Master of Science (Engineering)**,
Indian Institute of Science, Bengaluru
Department: Electrical Communication Engineering
Thesis: Sequential Controlled Sensing to Detect an Anomalous Process
Supervisor: Prof. Rajesh Sundaresan
GPA: 7.0/8.0

Aug'10 - Jul'14 **Bachelor of Engineering,**
R V College of Engineering, Bengaluru
Major: Electronics and Communications
GPA: 9.72/10.00 (rank 2 among 140 students)

Awards and Honors

- First place in the 100 seconds competition organised by INAE Kanpur Chapter
- Best paper award at the 2020 EECS Research Students' Symposium, Indian Institute of Science
- Best 3-minute presentation, ECE Students' Seminar Series, Department of ECE, Indian Institute of Science
- Rank 136 (among the top 0.01%) in the 2015 Graduate Aptitude Test in Engineering
- Infineon India scholarship for securing rank 2 in the 2011 Visvesvaraya Technological University examinations.
- Rank 23 (among the top 0.02%) in the 2010 Karnataka Common Entrance Test

Publications

Preprints

1. *Optimal Best Arm Identification in Linear Transfer Bandits*
   Bharati K, P. N. Karthik, Vincent Y. F. Tan, and Krishna Jagannathan
   Submitted, Feb 2023
2. *Federated Best Arm Identification with Heterogeneous Clients* arxiv
   Chen Zhirui, P. N. Karthik, Vincent Y. F. Tan, and Yeow Meng Chee
   Submitted, Oct 2022
3. *Learning to Detect an Odd Restless Markov Arm with a Trembling Hand* arxiv
   P. N. Karthik and Rajesh Sundaresan
4. *Axiomatic Characterisation of Projection Rules: An Open Question* draft
   P. N. Karthik and Rajesh Sundaresan

Journal Publications

1. *Bus Priority lane in Bengaluru: A Study of its Effectiveness and Driver Stress* pdf
   P. N. Karthik, Nihesh Rathod, Sarath Yasodharan, Wilson Lobo,
   Ajeesh Sahadevan, Rajesh Sundaresan and Pratik Verma
   Accepted, Special Issue on Sustainable City Transportation in the Indian Subcontinent, Transport Policy Journal, May 2023
2. *Best Arm Identification in Restless Markov Multi-Armed Bandits* arxiv xplore
   P. N. Karthik, Kota Srinivas Reddy, and Vincent Y. F. Tan
   IEEE Transactions on Information Theory, May 2023
3. *Detecting an Odd Restless Markov Arm with a Trembling Hand* arxiv xplore pdf
   P. N. Karthik and Rajesh Sundaresan
   IEEE Transactions on Information Theory, Aug 2021
4. *Learning to Detect an Odd Markov Arm* arxiv xplore pdf
   P. N. Karthik and Rajesh Sundaresan
   IEEE Transactions on Information Theory, Jul 2020

Doctoral Dissertation

- *Sequential Controlled Sensing to Detect an Anomalous Process* pdf source etd iisc
  Ph.D. thesis, Department of ECE, Indian Institute of Science, Nov 2021

Conference Publications

1. *Best Arm Identification in Bandits with Limited Precision Sampling*
   Kota Srinivas Reddy, P. N. Karthik, Nikhil Karamchandani, and Jayakrishnan Nair
   Accepted, IEEE International Symposium on Information Theory (ISIT 2023), Jun 2023
2. *Almost Cost-Free Communication in Federated Best Arm Identification* arxiv pdf
   Kota Srinivas Reddy, P. N. Karthik, and Vincent Y. F. Tan
   37th AAAI Conference on Artificial Intelligence (AAAI 2023), Feb 2023
3. *Best Restless Markov Arm Identification* xplore pdf
   P. N. Karthik, Kota Srinivas Reddy, and Vincent Y. F. Tan
   IEEE Information Theory Workshop (ITW 2022), Nov 2022
4. *Learning to Detect an Odd Restless Markov Arm* xplore pdf
   P. N. Karthik and Rajesh Sundaresan
   IEEE International Symposium on Information Theory (ISIT 2021), Jul 2021
5. *Detecting an Odd Restless Markov Arm with a Trembling Hand* xplore pdf
   P. N. Karthik and Rajesh Sundaresan
   IEEE International Symposium on Information Theory (ISIT 2020), Jun 2020
6. *Learning to Detect an Odd Markov Arm* xplore pdf
   P. N. Karthik and Rajesh Sundaresan
   IEEE International Symposium on Information Theory (ISIT 2019), Jul 2019
7. *On The Equivalence of Projections in Relative α-Entropy and Rényi Divergence* arxiv xplore pdf
   P. N. Karthik and Rajesh Sundaresan
   National Conference on Communications (NCC 2018), Feb 2018
8. *Model-Based Interference Cartography and Visualization* xplore pdf
   P. N. Karthik, Raksha Ramakrishna, Geethu Joseph, Chandra R. Murthy,
   Joyson Sebastian, and Neelesh B. Mehta
   National Conference on Communications (NCC 2016), Mar 2016

Ph.D. Mentorship Assistance

Candidate: Bharati Kamakoti (Ph.D., 3rd year)
Supervisor: Prof. Krishna Jagannathan
Institute: IIT Madras
Topic: Transfer learning

Candidate: Chen Zhirui (Ph.D., 2nd year)
Supervisor: Prof. Vincent Y. F. Tan
Institute: National University of Singapore
Topic: Federated learning

Research Projects

1. **Best Arm Identification in Multi-Armed Bandits**
   National University of Singapore, Singapore Jan'22 – present
   - Performance characterisation for restless Markov multi-armed bandits with known or unknown transition probability matrices using ideas from Markov decision processes
     Preliminary results published in ITW 2022 and IEEE Transactions on Information Theory
   - Design of sequential algorithms for federated learning bandits with or without communication costs and differential privacy constraints
     Preliminary results published in AAAI 2023
   - Performance characterisation for linear transfer bandits with known or unknown transfer function; design of algorithms capable of handling non-unique allocations
     Preliminary results submitted to COLT 2023
   - Performance characterisation when the learner has limited precision for selecting the arms
     Preliminary results accepted to ISIT 2023
   - Collaborators:
     - Prof. Vincent Y. F. Tan (faculty member, National University of Singapore).
     - Prof. Ali Tajer (faculty member, Rensselaer Polytechnic Institute).

- Prof. Nikhil Karamchandani (faculty member, IIT Bombay).
- Prof. Jayakrishnan Nair (faculty member, IIT Bombay).
- Prof. Krishna Jagannathan (faculty member, IIT Madras).
- Dr. Kota Srinivas Reddy (DST–INSPIRE faculty fellow, IIT Madras).
- Chen Zhirui (Ph.D. candidate, National University of Singapore)
- Arpan Mukherjee (Ph.D. candidate, Rensselaer Polytechnic Institute).
- Bharati Kamakoti (Ph.D. candidate, IIT Madras).

2. **Bus Priority Lane in Bengaluru: Effect on Travel Times and Driver Stress**
   Netradyne Technology India Pvt. Ltd., Bengaluru Nov'19 – Mar'20
   In collaboration with Bengaluru Metropolitan Transport Corporation
   - Studied the effectiveness of the bus priority lane (for the exclusive use of public transport buses) in Bengaluru in terms of reducing travel times and driver stress levels
   - Handled large datasets (150 Gigabytes of accelerometer and GPS data per month) using Python libraries (pandas, numpy, scikit)
   - Deployed Microsoft PowerBI and Kepler GL for geospatial analytic data visualisation
   - Extracted the bus travel times from GPS data using a novel "geofencing" technique
   - Proposed a novel metric for measuring driver stress levels
   - Findings accepted for publication in Transport Policy journal
   - Collaborators:
     - Dr. Sarath Yasodharan (postdoc, Brown University)
     - Dr. Nihesh Rathod (bioinformatician, Strand Life Sciences)
     - Prof. Rajesh Sundaresan (project coordinator and faculty member, Indian Institute of Science)
     - Dr. Ajeesh Sahadevan (Netradyne)
     - Pratik Verma (team lead, Netradyne)
     - Wilson Lobo (depot manager, Bengaluru Metropolitan Transport Corporation)

3. **Anomaly Identification in Multi-Armed Bandits**
   Indian Institute of Science, Bengaluru Jul'15 – Mar'22
   - Analysed the problem of finding an anomalous process (arm) in a multi-armed bandit as quickly as possible, subject to an upper bound on the error probability (target applications: neuroscience, power systems, communication networks)
   - Modeled each arm as a Markov chain on a finite state space
   - Provided the first-known lower and upper bounds on the limiting growth rate of the expected time to find the anomalous arm as the error probability vanishes for two distinct settings: rested bandits and restless bandits
   - Fingings published in ISIT 2019, ISIT 2020, ISIT 2021, and IEEE Transactions on Information Theory

Research Presentations

2023

1. *Best Arm Identification with Limited Precision Sampling* slides
   A talk given to Prof. Vincent Tan's research group at NUS, Feb 2023
2. *Almost Cost-Free Communication in Federated Best Arm Identification* poster
   Poster presentation, 37th AAAI Conference on Artificial Intelligence,
   Walter E. Washington Convention Center, Washington D.C., Feb 2023
3. *Almost Cost-Free Communication in Federated Best Arm Identification* slides
   Invited talk, Workshop on Information Theory and Data Science,
   Institute for Mathematical Sciences, National University of Singapore, Jan 2023

2022

1. *Best Restless Markov Arm Identification* slides
   IEEE Information Theory Workshop, Mumbai, India, Nov 2022
2. *Behind the Scenes of $Ax = b$: Axioms and an Open Question* slides video
   A talk given to Prof. Vincent Tan's research group, Mar 2022

2021

1. *Sequential Controlled Sensing to Detect an Anomalous Process* slides video
   Ph.D. defence, Department of ECE, Indian Institute of Science, Nov 2021
2. *Finding a Markov Anomaly Quickly and Accurately* video certificate
   100 seconds competition organised by INAE Kanpur Chapter, Oct 2021
   First place under "Electronics and Communication Engineering" category
3. *GATE 2022: A Pathway to Research* video
   An online interactive session on the Graduate Aptitude Test in Engineering as a pathway to research organised by the Division of EECS, Indian Institute of Science, Oct 2021
4. *Information Geometry and its Applications to Statistics* video notes
   An online lecture for the students of Indian Institute of Science, Sep 2021
5. *Learning to Detect an Odd Restless Markov Arm* slides video
   IEEE International Symposium on Information Theory, Jul 2021
6. *Sequential Controlled Sensing to Detect an Anomalous Process* slides video
   Ph.D. colloquium talk, Department of ECE, Indian Institute of Science, Jun 2021
7. *Crack Open the GATE* video
   A session conducted for the students of R V College of Engineering, May 2021
8. *Probability in Real-Life: Example Applications from Visual Neuroscience, Colour Blindness Detection, and Covid-19 Outbreak Modelling* slides video
   A talk presented virtually to the 5th semester students and the faculty of the Department of Electronics and Communication Engineering, R V College of Engineering, Sep 2020

2020

1. *Odd Arm Identification in Multi-armed Bandits with Markov Observations* slides video certificate
   EECS Research Students' Symposium, Indian Institute of Science, Jul 2020
   Best paper award under "Signal Processing, Communication Networks, and Information Theory" track
2. *Detecting an Odd Restless Markov Arm with a Trembling Hand* slides video
   IEEE International Symposium on Information Theory, Jun 2020
3. *Visual Search with a Trembling Hand: An Analysis of Odd Arm Identification in Restless Multi-armed Bandits* slides video
   Centre for Networked Intelligence, Indian Institute of Science, May 2020
4. *On Detecting an Anomalous Arm in a Multi-armed Bandit with Markov Observations* slides
   STCS Symposium, Tata Institute of Fundamental Research, Mumbai, Jan 2020

2019

1. *Search in Research: The Importance of the Theory of Probability in Real-Life* slides
   R V College of Engineering, Dec 2019
2. *Learning to Detect an Odd Markov Arm* slides
   Lectures on Probability and Stochastic Processes XIV, Indian Statistical Institute Delhi, Dec 2019
3. *On Detecting an Anomalous Arm in Multi-armed Bandits with Markov Observations* slides
   Networks Seminar, Robert Bosch Centre for Cyber Physical Systems, Indian Institute of Science, Nov 2019
4. *Learning to Detect an Odd Markov Arm* poster
   Joint Telematics Group Summer School, Indian Institute of Technology, Madras, Aug 2019
5. *Learning to Detect an Odd Markov Arm* slides
   Program on Advances in Applied Probability, International Centre for Theoretical Sciences, Aug 2019
6. *Learning to Detect an Odd Markov Arm* slides
   IEEE International Symposium on Information Theory, Jul 2019
7. *A Short Course on Probability and Random Processes* course material
   R V College of Engineering, Jun 2019

8. *$Ax = b$: A Familiar Setup, Axioms and An Open Question* slides
   ECE Students' Seminar Series, Department of Electrical Communication Engineering,
   Indian Institute of Science, FEB 2019

2018 AND EARLIER

1. *On the Equivalence of Projections in Relative α-Entropy and Rényi Divergence* slides
   National Conference on Communications,
   Indian Institute of Technology, Hyderabad, FEB 2018
2. *On the Equivalence of Projections in Relative α-Entropy and Rényi Divergence* slides
   Lectures on Probability and Stochastic Processes XII,
   Indian Statistical Institute, Kolkata, DEC 2017

PH.D. COURSEWORK

• Analysis – 1 (Real Analysis) • Analysis – 2 (Measure Theory) • Information Theory • Detection and Estimation Theory
• Random Processes • Error Correcting Codes • Calculus on Manifolds • Ordinary Differential Equations
• Online Prediction and Learning • Topics in Information Theory and Statistical Learning • Large Deviations
• Data Analytics • Concentration Inequalities

PROFESSIONAL SERVICE

- Reviewer, IEEE Transactions on Information Theory
- Reviewer, IEEE Transactions on Signal Processing
- Reviewer, Journal on Selected Areas in Communications (JSAC)
- Reviewer, Conference on Decision and Control (CDC 2023)
- Reviewer, IEEE International Symposium on Information Theory (ISIT 2019, 2023)
- Reviewer, National Conference on Communications (NCC 2018)

SOFTWARE KNOWLEDGE

Python | Microsoft PowerBI | Notion | LaTeX | MATLAB

REFEREES

Prof. Rajesh Sundaresan
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Prof. Vincent Y. F. Tan
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