# P. N. Karthik

## Personal Data

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|---|---|
| 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. *Federated Best Arm Identification with Heterogeneous Clients* `arxiv`
   Chen Zhirui, P. N. Karthik, Vincent Y. F. Tan, and Yeow Meng Chee
   Submitted, IEEE Transactions on Information Theory, MAY 2023

2. *Optimal Best Arm Identification in Linear Transfer Bandits*
   Bharati K, P. N. Karthik, Vincent Y. F. Tan, and Krishna Jagannathan
   Submitted, FEB 2023

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* `elsevier` `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` `pdf`
   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* `arxiv`
   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 $\alpha$-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, best arm identification

CANDIDATE: Chen Zhirui (Ph.D., 2nd year)
SUPERVISOR: Prof. Vincent Y. F. Tan
INSTITUTE: National University of Singapore
TOPIC: Federated learning, best arm identification

# 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
   - 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 published in Transport Policy
- 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 video
   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 $\alpha$-Entropy and Rényi Divergence* `slides`
   National Conference on Communications,
   Indian Institute of Technology, Hyderabad, Feb 2018

2. *On the Equivalence of Projections in Relative $\alpha$-Entropy and Rényi Divergence* `slides`
   Lectures on Probability and Stochastic Processes XII,
   Indian Statistical Institute, Kolkata, Dec 2017

## Graduate 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
Professor, Department of ECE,
Indian Institute of Science
Email: rajeshs@iisc.ac.in

Prof. Vincent Y. F. Tan
Professor, Department of ECE,
National University of Singapore
Email: vtan@nus.edu.sg

Prof. Parimal Parag
Assoc. Professor, Department of ECE,
Indian Institute of Science
Email: parimal@iisc.ac.in

Prof. Navin Kashyap
Professor, Department of ECE,
Indian Institute of Science
Email: nkashyap@iisc.ac.in

Prof. Himanshu Tyagi
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