

# P. N. KARTHIK



## PERSONAL DATA

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DATE OF BIRTH: 20 APR 1992  
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## RESEARCH INTERESTS

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

## EXPERIENCE

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- 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 (BMTCL))*
- 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**    **GRADUATE TEACHING ASSISTANT**  
**AUG'18 - DEC'18**    *Department of ECE, Indian Institute of Science, Bengaluru*  
**AUG'17 - DEC'17**    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

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- 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

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- 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

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### 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. *Bus Priority lane in Bengaluru: A Study of its Effectiveness and Driver Stress*  
[P. N. Karthik](#), Nihesh Rathod, Sarath Yasodharan, Wilson Lobo,  
Ajeesh Sahadevan, Rajesh Sundaresan and Pratik Verma  
Submitted, [Transport Policy Journal](#), JAN 2022
4. *Learning to Detect an Odd Restless Markov Arm with a Trembling Hand* [arxiv](#)  
[P. N. Karthik](#) and Rajesh Sundaresan
5. *Axiomatic Characterisation of Projection Rules: An Open Question* [draft](#)  
[P. N. Karthik](#) and Rajesh Sundaresan

### JOURNAL PUBLICATIONS

1. *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](#), 2022+
2. *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
3. *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](#)  
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: Best arm identification + transfer learning

CANDIDATE: Chen Zhirui (Ph.D., 2nd year)  
SUPERVISOR: Prof. [Vincent Y. F. Tan](#)  
INSTITUTE: National University of Singapore  
TOPIC: Best arm identification + transfer 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](#); more recent results submitted to [ICML 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:**

- Bharati Kamakoti (Ph.D. candidate, IIT Madras)
- Chen Zhirui (Ph.D. candidate, National University of Singapore)
- Dr. [Kota Srinivas Reddy](#) (DST-INSPIRE faculty fellow, IIT Madras)
- Prof. [Vincent Y. F. Tan](#) (faculty member, National University of Singapore)
- Arpan Mukherjee (Ph.D. candidate, Rensselaer Polytechnic Institute)
- Prof. [Ali Tajer](#) (faculty member, Rensselaer Polytechnic Institute)
- Prof. [Nikhil Karamchandani](#) (faculty member, IIT Bombay)
- Prof. [Jayakrishnan Nair](#) (faculty member, IIT Bombay)

## 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 submitted to the [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
- Results 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  $\alpha$ -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

## PROFESSIONAL SERVICE

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- 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

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Python | Microsoft [PowerBI](#) | [Notion](#) |  $\text{\LaTeX}$  | MATLAB

## REFEREES

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Prof. [Rajesh Sundaresan](#)  
Professor, Department of ECE,  
Indian Institute of Science  
EMAIL: [rajeshs@iisc.ac.in](mailto:rajeshs@iisc.ac.in)

Prof. [Vincent Y. F. Tan](#)  
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National University of Singapore  
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Prof. [Parimal Parag](#)  
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Prof. [Navin Kashyap](#)  
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Indian Institute of Science  
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Prof. [Himanshu Tyagi](#)  
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Prof. [Utpal Mukherji](#)  
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