

ANKUR A. KULKARNI

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Systems and Control Engineering
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ACADEMIC AND PROFESSIONAL CAREER

Associate Professor, Systems and Control Engineering, Kelkar Family Chair in Quantitative Finance	May 2018 – present Jan 2023 – present
Affiliated faculty, Center for Machine Intelligence and Data Science	
Affiliated faculty, Koita Centre for Digital Health	
Affiliated faculty, IIT Bombay Trust Lab Indian Institute of Technology Bombay.	
Assistant Professor, Systems and Control Engineering, Indian Institute of Technology Bombay.	Jan 2013 – May 2018
Post-doctoral Research Associate, Coordinated Science Laboratory, University of Illinois at Urbana-Champaign	Jan 2011 – Dec 2012
Instructor, University of Illinois at Urbana-Champaign	
Undergraduate course: <i>Introduction to Operations Research</i>	Fall 2010
Undergraduate course: <i>Engineering Economy</i>	Fall 2011
Ph.D., Industrial Engineering, University of Illinois at Urbana-Champaign.	Dec 2010
M.S., General Engineering, University of Illinois at Urbana-Champaign.	May 2008
B.Tech., Aerospace Engineering, Indian Institute of Technology Bombay.	May 2006

AWARDS AND HONOURS

- **Kelkar Family Chair in Quantitative Finance** at IIT Bombay
- Member of the **IT-Project Advisory Committee of the Securities and Exchange Board of India**
- Research advisor (**Visiting Principal Scientist**) with **Tata Consultancy Services**
- Member, **Technical Evaluation Committee, Maha-IT (a Govt of Maharashtra Enterprise)**
- **Associate** of the Indian Academy of Sciences, Bangalore (2015–2018)
- **INSPIRE Faculty Award** by the Department of Science and Technology, India, 2013-2018.
- **Excellence in Teaching Award** 2018, IIT Bombay.
- **Excellence in Ph.D. Research Award** 2019, awarded to my Ph.D. student, IIT Bombay.
- **Best paper award** at the Indian Control Conference, Chennai, 2022.
- **Best paper award** at the Indian Control Conference, Kanpur, 2018.
- **Runner-up best paper award** at the International Conference on Signal Processing and Communications (SPCOM), 2018.
- **Best paper award** at the National Conference on Communications, Chennai, 2017.

- **William A. Chittenden Award** for an Outstanding Master of Science Graduate in General Engineering.
- Listed on **The Incomplete List of Teachers Ranked as Excellent** by their Students, Spring 2007.

VISITING POSITIONS

Visitor July 2019
 Visiting Prof Vincent Y. F. Tan
 Department of Electrical and Computer Engineering, National University of Singapore, Singapore

Visitor Apr–May 2019
 Visitor as part of the programme on Mathematics of Energy Systems
 Isaac Newton Institute for Mathematical Sciences, University of Cambridge, Cambridge, UK.

Visitor May 2018
 Visiting Prof Sanjoy Mitter
 Laboratory for Information and Decision Systems, Massachusetts Institute of Technology, Cambridge, USA.

Visitor June 2014 – July 2014
 Visiting Prof Karl Henrik Johansson
 Department of Automatic Control, KTH Royal Institute of Technology, Stockholm, Sweden.

Visiting Scholar May 2008 – Aug 2008
 Visiting Prof Vivek S. Borkar
 School of Technology and Computer Science, Tata Institute of Fundamental Research

Short visits 2012 – 2017
 Indian Institute of Science, Bangalore, University of Illinois at Urbana-Champaign, Pennsylvania State University, University of Paris-Dauphine.

RESEARCH INTERESTS

I am a systems theorist with an interest in systems with strategic agents and informational complexities. I do fundamental research on game theory, information theory, stochastic control and operations research. My recent work is on problems such as security, stealth, nudging and, information disclosure and elicitation.

PUBLICATIONS

Journal

1. Reema Deori and Ankur A. Kulkarni, “*Information Revelation Through Signalling*”, Systems and Control Letters, (2022).
2. Karan N. Chadha and Ankur A. Kulkarni, “*On Independent Cliques and Linear Complementarity Problems*”, Indian Journal of Pure and Applied Mathematics, (2022).
3. Anuj S. Vora and Ankur A. Kulkarni, “*Minimax theorems for finite blocklength lossy joint source-channel coding over an arbitrarily varying channel*”, Problems of Information Transmission, Volume 57, Issue 2, pp 99–128, (2021).
4. Indu Yadav, Ankur A. Kulkarni and Abhay Karandikar, “*Strategy-Proof Spectrum Allocation among Multiple Operators for Demand Varying Wireless Networks*”, IEEE Transactions on Vehicular Technology, Volume 69, Issue 12, pp 15694–15977, (2021).
5. Karan N. Chadha, Ankur A. Kulkarni and Jayakrishnan Nair, “*Efficiency Fairness Tradeoff in Battery Sharing*”, Operations Research Letters, Volume 49, Issue 3, (2021).
6. Vivek Deulkar, Jayakrishnan Nair, Ankur A. Kulkarni, “*Statistical Economies of Scale in Battery Sharing*”, Journal of Energy Storage, Volume 33, (2021).

7. Mathew Abraham and Ankur A. Kulkarni, “Price-coupling Games and the Generation Expansion Planning Problem”, *Annals of Operations Research*, Volume 295, pp 1–19, (2020).
8. Vivek Deulkar, Jayakrishnan Nair and Ankur A. Kulkarni, “Sizing Storage for Reliable Renewable Integration: A Large Deviations Approach”, *Journal of Energy Storage*, Volume 30, (2020).
9. Karan N. Chadha and Ankur A. Kulkarni, “Aggregate Play and Welfare in Strategic Interactions on Networks”, *Journal of Mathematical Economics*, Vol 88, pp 72–86, (2020).
10. Sharu Theresa Jose and Ankur A. Kulkarni, “Shannon meets von Neumann: A Minimax Theorem for Channel Coding in the Presence of a Jammer”, *IEEE Transactions on Information Theory*, Vol 66, issue 5, pp 2842–2859 (2020).
11. Ankur A. Kulkarni, “Near-Optimality of Linear Strategies for Static Teams with ‘Big’ Non-Gaussian Noise”, *IEEE Transactions on Automatic Control*, Vol 65, Issue 2, pp 534–545 (2020).
12. Sharu Theresa Jose and Ankur A. Kulkarni, “Improved Finite Blocklength Converses for Slepian-Wolf Coding via Linear Programming”, *IEEE Transactions on Information Theory*, Vol 65, issue 4, pp 2423–2441(2018).
13. Mathew Abraham and Ankur A. Kulkarni, “An ADMM-Based Algorithm for Solving DC-OPF in a Large Electricity Network Considering Transmission Losses”, *IET Generation, Transmission and Distribution*, Vol 12, Issue 21, pp 5811-5823 (2018).
14. Mathew P. Abraham and Ankur A. Kulkarni, “New Results on the Existence of Open Loop Nash Equilibria in Discrete Time Dynamic Games via Generalized Nash Games”, (in press, published online) *Mathematical Methods of Operations Research*, (2017).
15. Ankur A. Kulkarni, “Local and Networked Mean-Square Estimation with High Dimensional Log-concave Noise”, *IEEE Transactions on Information Theory*, Vol 64, Issue 4, pp 2759 - 2773 (2018).
16. Parthe Pandit and Ankur A. Kulkarni, “A linear complementarity based characterization of the weighted independence number and the independent domination number in graphs”, *Discrete Applied Mathematics*, Volume 244, pp 155–169 (2018).
17. Parthe Pandit and Ankur A. Kulkarni, “Refinement of the Equilibrium of Public Goods Games over Networks: Efficiency and Effort of Specialized Equilibria”, in press, *Journal of Mathematical Economics*, (2018).
18. Sharu Theresa Jose and Ankur A. Kulkarni, “Linear Programming based Converses for Finite Block-length Lossy Joint Source-Channel Coding”, *IEEE Transactions on Information Theory*, Vol 63, Issue 11, pp 7066–7094 (2017).
19. Mathew P. Abraham and Ankur A. Kulkarni, “An Approach Based on Generalized Nash Games and Shared Constraints for Discrete Time Dynamic Games”, *Dynamic Games and Applications*, Vol 8, Issue 4, pp 641–670 (2018).
20. Ankur A. Kulkarni, “Games and Teams With Shared Constraints” *Philosophical Transactions of the Royal Society*, Vol 375, Issue 2100, (2017) (**invited paper**).
21. Daniel Cullina, Negar Kiyavash and Ankur A. Kulkarni “Restricted Composition Deletion Correcting Codes”, *IEEE Transactions on Information Theory*, Vol 62, Issue 9, pp 4819–4832 (2016).
22. Ankur A. Kulkarni and Uday V. Shanbhag, “An Existence Result for Hierarchical Stackelberg v/s Stackelberg Games”, *IEEE Transactions on Automatic Control*, Vol 60, No 12, pp 3379–3384 (2015).
23. Ankur A. Kulkarni and Todd P. Coleman, “An Optimizer’s Approach to Stochastic Control Problems with Nonclassical Information Structures”, *IEEE Transactions on Automatic Control*, Vol 60, No 4, pp 937–949 (2015).
24. Ankur A. Kulkarni and Uday V. Shanbhag, “A Shared-Constraint Approach to Multi-leader Multi-follower Games”, *Set Valued and Variational Analysis*, 22(4), pp 691–720, (2014).
25. Ankur A. Kulkarni, Negar Kiyavash and R. Sreenivas, “On the Varshamov-Tenengolts Construction on Binary Strings”, Vol 317, *Discrete Mathematics*, pp 79–90, (2014).
26. Ankur A. Kulkarni and Negar Kiyavash, “Non-asymptotic Upper Bounds for Deletion Correcting Codes”, *IEEE Transactions on Information Theory*, 59(8), pp 5115–5130, (2013).

27. Ankur A. Kulkarni and Uday V. Shanbhag, “Revisiting Generalized Nash Games and Variational Inequalities”, *Journal of Optimization Theory and Applications* 154(1), (2012).
28. Ankur A. Kulkarni and Uday V. Shanbhag, “On the Variational Equilibrium as a Refinement of the Generalized Nash Equilibrium”, *Automatica* 48(1), pp. 45–55, (2012).
29. Ankur A. Kulkarni and Uday V. Shanbhag, “Recourse-based Stochastic Nonlinear Programming: Properties and Benders-SQP Algorithms”, *Computational Optimization and Applications* (2010).
30. Ankur A. Kulkarni and Vivek S. Borkar “Finite Dimensional Approximation and Newton-based Algorithm for Stochastic Approximation in Hilbert Space”, *Automatica* 45(12), pp. 2815—2822, (2009).

Conference

1. Reema Deori and Ankur A. Kulkarni, “Zero-error Communication with an Influencer”, to appear National Conference on Communications, 2023.
2. Manish K. Singh and Ankur A. Kulkarni, “Strategic Multiclass Classification with Non-uniform Preferences and its Relation to Incentive Compatibility”, Indian Control Conference 2022 (**Best student paper award**).
3. Anuj S. Vora and Ankur A. Kulkarni, “Optimal Questionnaires for Screening of Strategic Agents”, ICASSP 2021 (**invited paper**).
4. Anuj S. Vora and Ankur A. Kulkarni, “Information Extraction from a Strategic Sender over a Noisy Channel”, Proceedings of the IEEE Conference on Decision and Control, 2020.
5. Anuj S. Vora and Ankur A. Kulkarni, “Zero Error Strategic Communication”, Proceedings of SPCOM 2020.
6. Anuj S. Vora and Ankur A. Kulkarni, “Achievable Rates for Strategic Communication”, Proceedings of the International Symposium on Information Theory, 2020.
7. Anuj S. Vora and Ankur A. Kulkarni, “Communicating with a Strategic Sender”, Proceedings of the National Conference on Communications 2020.
8. Ankur A. Kulkarni and Anupama Kowli, “Addressing the Free-Rider Problem in Voluntary Demand Response Programs”, accepted by the Indian Control Conference, 2019.
9. Indu Yadav, Ankur A. Kulkarni and Abhay Karandikar, “Strategy-proof Spectrum Allocation among Multiple Operators”, Proceedings of IEEE Wireless Communications and Networking Conference, 2019.
10. Vivek Deulkar, Jayakrishnan Nair and Ankur A. Kulkarni, “Sizing Storage for Reliable Renewable Integration”, Proceedings of PowerTech 2019.
11. Anuj S. Vora and Ankur A. Kulkarni, “A Minimax Theorem for Finite Blocklength Joint Source-Channel Coding over an AVC”, to appear in the Proceedings of the National Conference on Communications, 2019.
12. Mansi Sood, Sharayu Moharir and Ankur A. Kulkarni, “Pricing and Commission in Two-Sided Markets with Free Upgrades”, accepted by Lecture Notes in Computer Science, 2018.
13. Sharu Theresa Jose and Ankur A. Kulkarni, “On a Game Between a Delay-constrained Communication System and a Finite State Jammer”, Proceedings of the IEEE Conference on Decision and Control (2018).
14. Sharu Theresa Jose and Ankur A. Kulkarni, “A Linear Programming Based Finite Blocklength Converse for Asymmetric Multiple Access Channels”, to appear in the Proceedings of SPCOM, (2018) (**Runner best paper award**).
15. Mansi Sood, Ankur A. Kulkarni, Sharayu Moharir, “Platform Competition for Throughput in Two-sided Freelance Markets”, to appear in the Proceedings of SPCOM, (2018).
16. Mansi Sood, Sharayu Moharir and Ankur A. Kulkarni “Pricing in Two-Sided Markets in the Presence of Free Upgrades”, to appear in the Proceedings of COMSNETS (2018).
17. Mathew P. Abraham and Ankur A. Kulkarni, “On the Existence of Equilibria in Price-Coupling Games”, to appear in the Proceedings of the Indian Control Conference, (2018) (**Best student paper award**).

18. Sharu Theresa Jose and Ankur A. Kulkarni, “*Linear programming based converses for some network-like problems.*”, to appear in the Proceedings of the IEEE Information Theory Workshop, (2017).
19. Smita Solanki and Ankur A. Kulkarni, “*Separating the Good from the Bad in Rating Systems: A Framework and Numerical Evidence*”, 2017 IEEE International Conference on Signal Processing, Informatics, Communication and Energy Systems (SPICES), (2017).
20. Sharu Theresa Jose and Ankur A. Kulkarni, “*A Linear Programming Based Channel Coding Strong Converse for the BSC and BEC*”, Proceedings of the Twenty-third National Conference on Communications, Chennai, India (2017) (**Best paper award**).
21. Parthe Pandit and Ankur A. Kulkarni, “*Non-constructive Lower Bounds for Binary Asymmetric Error Correcting Codes*”, Proceedings of the Twenty-third National Conference on Communications, Chennai, India (2017).
22. Ankur A. Kulkarni, “*Mean-square estimation with high dimensional log-concave noise*” Proceedings of the the IEEE Conference on Decision and Control, pp 2029–2034, Las Vegas, USA (2016).
23. Ankur A. Kulkarni, “*Approximately Optimal Linear Strategies for Static Teams with ‘Big’ Non-Gaussian Noise*”, Proceedings of the IEEE Conference on Decision and Control, Osaka, Japan, pp 7177–7182 (2015).
24. Sharu Theresa Jose and Ankur A. Kulkarni, “*A Linear Programming Relaxation for Stochastic Control Problems with Non-Classical Information Patterns*”, Proceedings of the IEEE Conference on Decision and Control, Osaka, Japan, pp 5743–5748 (2015).
25. Bharat Prabhakar and Ankur A. Kulkarni, “*Dimensionality Reduction of Affine Variational Inequalities Using Random Projections*” Proceedings the Allerton Conference, Monticello, USA, pp 256–263 (2014).
26. Ankur A. Kulkarni, “*Insertion and Deletion Errors with a Forbidden Symbol*” Proceedings of the IEEE Information Theory Workshop, Hobart, Australia, pp 596–560 (2014).
27. Ankur A. Kulkarni and Uday V. Shanbhag, “*On the Consistency of Leaders’ Conjectures in Hierarchical Games*”, Proceedings of the IEEE Conference on Decision and Control, Florence, Italy, pp 1180–1185 (2013).
28. Ankur A. Kulkarni and Todd P. Coleman, “*An Optimizer’s approach to Stochastic Control Problems with Nonclassical Information Structure*”, Proceedings of the IEEE Conference on Decision and Control, Maui, USA, pp 154-159 (2012)..
29. Daniel Cullina, Ankur A. Kulkarni, and Negar Kiyavash, “*A Coloring Approach to Constructing Deletion Correcting Codes from Constant Weight Subgraphs*”, Proceedings of IEEE International Symposium on Information Theory, Boston, USA, pp 513–517 (2012).
30. Ankur A. Kulkarni and Uday V. Shanbhag, “*New Insights on Generalized Nash Games with Shared Constraints: Constrained and Variational Equilibria*”, Proceedings of the IEEE Conference on Decision and Control, Shanghai, China, pp 151-156 (2009).
31. Wei Chen, Dayu Huang, Ankur A. Kulkarni, Jayakrishnan Unnikrishnan, Quanyan Zhu, Prashant Mehta, Sean Meyn, Adam Wierman, “*Approximate Dynamic Programming using Fluid and Diffusion Approximations with Applications to Power Management*”, Proceedings of the IEEE Conference on Decision and Control, Shanghai, China, pp 3575–3580 (2009).
32. Ankur A. Kulkarni, Albert Rossi, Jay Alameda and Uday V. Shanbhag, “*A Grid-Computing Framework for Quadratic Programming Under Uncertainty*”, Proceedings of the TeraGrid, pp 4–8, 2007.

PAPERS UNDER REVIEW

- J3 Anuj S. Vora and Ankur A. Kulkarni “*Shannon meets Myerson: Information extraction from a strategic sender*”, under review with Games and Economic Behavior.
- J2 Shashank A. Deshpande and Ankur A. Kulkarni, “*The Quantum Advantage in Decentralized Control*”, under review with Automatica, 2022.

J1 Shraddha Pathak and Ankur A. Kulkarni, “A Scalable Bayesian Persuasion Framework for Epidemic Containment on Heterogeneous Networks”, under review with the Journal of Mathematical Economics, 2022.

STUDENT GUIDANCE

- 4 Ph.D. students guided (3 sole guide, 1 co-guided), 4 ongoing (3 sole guide, 1 co-guide)
- 10+ M.Tech., B.Tech. theses guided
- Post-docs 2 (1 mentored, 1 on-going)

TEACHING RELATED ACTIVITIES

Course development

- *Designed* the novel course on stochastic control and information theory ‘SC 643: Stochastic and Networked Control’ at IIT Bombay.
- *Designed* the popular and unique course ‘SC 631: Games and Information’ at IIT Bombay.
- *Designed* the advanced course ‘SC 632: Variational Analysis and Polyhedral Geometry’ at IIT Bombay.
- *Revamped* the course ‘SC 607: Optimization’ at IIT Bombay.
- **NPTEL courses:** Optimization from Fundamentals, Stochastic control and Communication, Games and Information.

Course feedback scores at IIT Bombay

Average teaching score of 90+ out of 100 over 10 years of teaching. Detailed scores can be provided on request.

QIP/CEP Designed and offered the following courses under the Continuing Education Programme, IIT Bombay

- For working professionals on ‘Artificial intelligence and machine learning with applications to finance’, 2020. Total registration 50. Delivered modules on AI and optimization and AI and multiagent systems.
- For the National Technical Research Organization on ‘Game Theory for Security’, 2020. Total registration 30.
- For working professionals and college teachers on ‘Optimization and Game Theory’, 2015. Total registration 50.

FUNDED PROJECTS

#	Title and PI/co-PI	Funding agency	Amount	Duration
1	Games, Control and Optimization with Shared Constraints (INSPIRE Faculty Award). Sole PI.	Department of Science and Technology	35 lakhs	2013-18
2	Towards a Convex-Analytic view of Information Structures. Sole PI.	IRCC, IIT Bombay	20 lakhs	2013-18
3	Approximation of High-Dimensional Optimization and Control Problems. Co-PI Vivek S. Borkar.	Science and Engineering Research Board	30 lakhs	2015-18
4	Equilibria of Dynamic Games: An Optimization-based Approach. Sole PI.	Science and Engineering Research Board	17 lakhs	2015-18
5	SPORES: SMART Planning and Operations of Grids with Renewables and Storage. One of the main investigators in a consortium led by IITB.	Department of Science and Technology	2.56 crores	2018-21

6.	Information Design for Socio-Technical Systems. Co-PI Rajesh Sundaresan	Science and Engineering Research Board.	60 lakhs	2020-23
7.	Signalling for Real-time Control in the Smart Grid. Co-PI Anupama Kowli, Rene Aid (Univ of Paris)	Indo-French Centre for Promotion of Advanced Research	90 lakhs	2021-24
8.	Unified convex Analytic Approach for Network Information Theory. Sole PI	Science and Engineering Research Board	6 lakhs	2020-23
9.	Selling Renewable Generation to Flexible Consumers with a Data-Driven Tariff Scheme. Co-PI Abhishek Gupta (OSU)	IITB-OSU Frontier Center	30 lakhs	2020-22

CONSULTANCY

#	Title and PI/co-PI	Funding agency	Amount	Duration
1.	Analysis related to Algorithmic Trading, HFT & Colocation in Indian securities market. Sole PI. <i>Consultant to the Securities and Exchange Board of India on devising regulatory strategies for high frequency trading. Designed a quantitative framework based on game theory and stochastic control for analyzing and devising scheduling rules (randomization, speed bumps, resting time etc) and information flows (tick-by-tick data feed, colocation access) to ensure a level playing field for all market participants and to control price volatility in the Indian securities market, in the face of high frequency algorithmic trading.</i>	Securities and Exchange Board of India (SEBI)	17 lakhs	1.5 years
2.	Agent-based Model for Sales Agents in Insurance. Sole PI.	HDFC Life Insurance Company	5 lakhs	6 months
3.	Analytics for Anti-Money Laundering	Kotak Mahindra Bank Limited	15 lakhs	9 months
4.	Online-detection of Anomalous Behaviour in Active Directory Logins	Kotak Mahindra Bank Limited	9 lakhs	6 months
5.	Research advisory in the role of Visiting Principal Scientist. <i>Guiding research pertaining to bargaining for bill discounting, bidding in electricity markets, and asynchronous learning.</i>	Tata Consultancy Services	9 lakhs	1 year

TECHNOLOGY/KNOWLEDGE TRANSFER

1. Six out eight main recommendations of my report to SEBI arising from project 1 above were accepted and are presently implemented in the Indian securities market
2. Three algorithms were developed in project 3 for Kotak Mahindra Bank. Of these two are presently being employed for anti-money laundering activities
3. Algorithm developed in project 4 for Kotak Mahindra Bank has been transferred to the client and is presently in the stage of implementation

OTHER PROFESSIONAL ACTIVITIES

Technical programme committee/chair

- Program chair, Indian Control Conference 2023

- Member, TPC of IEEE Information Theory Workshop, American Control Conference, Indian Control Conference, International Conference on Control, Decision and Information Technologies, International Joint Conference on Artificial Intelligence, International Conference on Signal Processing and Communication (SPCOM), National Conference on Communications for several years

Session chair at international conferences

- *Session co-chair* and *session organizer* for session on “50 Years of Witsenhausen’s Counterexample” at the IEEE Conference on Decision and Control, Miami, USA 2018.
- *Session chair* for session “Information Theory” at the International Conference on Signal Processing and Communication (SPCOM), Bangalore, India, 2018.
- *Session co-chair* for session on “Estimation” at the IEEE Conference on Decision and Control, Las Vegas, USA 2016.
- *Session co-chair* for sessions on “Information Theory and Control” and “Stochastic Optimal Control” at the IEEE Conference on Decision and Control, Osaka, Japan 2015.
- *Session chair* for session on “Online Optimization” at International Symposium on Mathematical Programming, Pittsburgh, USA, 2015.
- *Session chair* for session on “Coding for Distributed Storage” at SPCOM 2014.
- *Session co-chair* for session on “Optimization Theory” at the Allerton Conference, Monticello, USA 2014.
- *Session chair* For session on “Stochastic Programming” at the INFORMS Annual meeting, Seattle, USA 2007.

Organisation

- Workshop on “Optimization” for the National Centre for Mathematics, 2016
- Steering committee for the National Mathematics Initiative year on Optimization and Game Theory, 2015-16.
- *Organized* the Third IIT Bombay Winter School on Optimization and Control, 2014.

Reviewer for

- IEEE Transactions on Information Theory, Automatica, IEEE Transactions on Automatic Control, IEEE Journal on Selected Areas in Communications (*Game theory in Wireless Communications*), IEEE Transactions on Communications, Mathematical Programming, European Journal of Operations Research, Mathematical Methods of Operations Research, SIAM Journal on Optimization, IEEE Transactions on Signal Processing, Journal of Optimization Theory and Applications, Optimal Control, Applications and Methods, International Game Theory Review, Indian Journal of Pure and Applied Mathematics