

DR. SANJEEV KUMAR

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EDUCATION

PhD in Applied Mathematics; Indian Institute of Technology Roorkee Thesis area: Image Processing Advisors: Prof. N. Sukavanam and Prof. R. Balasubramanian (CSE, IIT Roorkee)	September 2008
M.Sc. in Applied Mathematics; Indian Institute of Technology Roorkee	June 2003

CURRENT RESEARCH INTERESTS

Image Processing (Image Restoration; Encryption and Visual Secret Sharing; Quantum Imaging, 3D Vision)
Machine Learning (Neural Networks; Generative Models; Applications)

PROFESSIONAL EXPERIENCE

- Professor, Department of Mathematics, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, 247 667, INDIA (01 August to present)
- Associate Professor, Department of Mathematics, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, 247 667, INDIA (29 April 2016 -31 July 2023)
- Assistant Professor, Department of Mathematics, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, 247 667, INDIA (18 November 2010 –28 April 2016)
- Postdoctoral Fellow, Department of Mathematics and Computer Science, University of Udine, ITALY (03 September 2008- 15 November 2010)

THESIS SUPERVISED

	Completed	Ongoing
Ph.D.	08	07
Masters (IMSc. Applied Mathematics)/B.Tech.	28	00
M.Tech.	02	01

AWARDS/HONORS

- Outstanding Teachers' Award for the Year 2019 for Under Graduate Category with citation and cash award of Rs. 100,000/- awarded by Indian Institute of Technology Roorkee (on Teachers Day)
- Selected in top 15 contenders of Outstanding Teachers' Award for the year 2018 for Under Graduate Category at IIT Roorkee
- Best Paper award for a research paper in "4th International Conference on Eco-friendly Computing and Communication Systems" 2015.
- Ministero dell'Istruzione, dell'Università e della Ricerca (MIUR) postdoctoral fellowship at university of udine Italy (2008-2010)
- CSIR Research Fellowship during PhD at IIT Roorkee during (2004-2008)

SPONSORED RESEARCH GRANTS

S. No.	Title of the Project	Sponsoring Agency	Financial layout (INR)	Investigators	Status
1.	Developing Deep Learning-based Strategies, Tools and Apps for Global Financial Market	SmartAlpha Ltd, Hyderabad	33.18 Lacs	Co-PI	Ongoing (2023-25)
2.	Development of Encryption and Secret Sharing Schemes for Quantum Images	SERB: Core Research Grant	20.53 Lacs	Principal Investigator	Ongoing (2021-24)
3.	Development of Advanced Computational Algorithms for Evaluating Post-Surgery Rehabilitation	DST: Indo-Czech research cooperation	32.03 Lacs	Principal Investigator	Ongoing (2020-23)
4.	Optical flow-based prediction of Visual storms from satellite image sequences	ISRO: RESPOND Scheme	16.80 Lacs	Principal Investigator	Completed (2017-19)
5.	Study and Development of Multi-Spectral Active Stereo Vision for Video Surveillance	SERB: Fast-track Young Scientist Scheme	5.30 Lacs	Principal Investigator	Completed (2013-16)
6.	3D reconstruction and software development for city model generation from satellite images	ISRO: RESPOND Scheme	7.73 Lacs	Co-PI	Completed (2012-2015)

COURSES TAUGHT IN LAST 5 YEARS

<ul style="list-style-type: none"> • Machine Learning • Linear Algebra • Mathematics-I (Multivariable Calculus) • Design and Analysis of Algorithms 	<ul style="list-style-type: none"> • Image Processing • Computer Vision • Database Management System
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TEACHING CONTRIBUTIONS/OUTREACH ACTIVITIES

- **NPTEL Courses:** (jointly with Prof. S. K. Gupta, IITR)
 - Essential Mathematics for Machine Learning (12 weeks)
 - Matrix Analysis with Applications (08 Weeks)
 - Multivariable Calculus (08 Weeks)
- **Training Program:** Short term training program on Machine Learning with Python funded by National Informatics Centre (NIC) New Delhi during June 2019
- **Curriculum/Courses Developed:**
 - Coordinated the development of curriculum for M.Tech. in AI and M.Tech. in Data Science for MFSDSAI at IIT Roorkee in 2021.
 - Developed courses on Applied Linear Algebra, Essential Mathematics for AI, Applied Machine Learning and Design and Analysis of Algorithms for UG and PG curriculum at MFSDSAI and Mathematics Department, IIT Roorkee

- **Online Certification program at CEC IIT Roorkee:**
 - Co-coordinator and instructor for IITR-Timespro PG Certification program in Data Science and Machine Learning at IIT Roorkee (2021 onwards)
 - Instructor in IITR-Coursera PG Certification program in Data Science and Machine Learning at IIT Roorkee (2022 onwards)

CONFERENCE/WORKSHOP/TRAINING PROGRAMS ORGANIZED

- Convener, International Conference on Computer Vision and Image Processing (CVIP 2016), IIT Roorkee, February 26-28, 2016
- Organizing Chair, Second International Conference on Computer Vision and Image Processing and Workshop on Multimedia (CVIP-WM 2017), IIT Roorkee, September 9-12, 2017.
- Program Chair, Third International Conference on Computer Vision and Image Processing (CVIP 2018), IIIT-DM Jabalpur, September 29-October 01, 2018.
- Conference Chair, Fifth International Conference on Computer Vision and Image Processing (CVIP 2020), IIIT Allahabad, December 04-06, 2020.
- Program Chair, Sixth IAPR International Conference on Computer Vision and Image Processing (CVIP 2021), IIT Roorkee, December 03-05, 2021.
- Conference Chair, Seventh IAPR International Conference on Computer Vision and Image Processing (CVIP 2022), NIT Nagpur, November 04-06, 2022.
- Convener, International Conference on Dynamical Systems, Control and Its Applications, IIT Roorkee, July 02-04, 2022
- Organized courses in the area of Image Processing, Machine Learning and Large Scale Scientific Computing at QIP Centre (under QIP and TEQIP schemes) IIT Roorkee.
- Organized four short term courses (FDP) in the area of Image Processing and Machine Learning at EICT Academy IIT Roorkee.

INTERNATIONAL/INDUSTRIAL COLLABORATIONS

- Research Collaboration with AVIRES Lab group at Department of Mathematics and Computer Science, University of Udine, Italy
- Research Collaboration with Centre for Mathematical Imaging Techniques at Department of Mathematical Sciences, University of Liverpool, UK
- Research Collaboration with Prof. Jan Mares group at Department of Mathematics, Informatics and Cybernetics, UCT Prague, Czech Republic
- SAC Ahmedabad, ISRO
- SmartAlpha Pvt Ltd. Hyderabad

ADMINISTRATIVE RESPONSIBILITIES

- Head, Institute Computer Centre IIT Roorkee from 01 December 2020 to present
- Member, Institute Web Management Committee from 01.12.2020 to present
- Core Committee member for Centre for AI & DS (MFSDSAI)
- Warden, Ganga Bhawan IIT Roorkee (June 2014 to May 2017)
- Staff Advisor at Institute Sports Council IIT Roorkee (June 2013 to May 2016)
- Institute Academic Program Committee Member (January 2013 to February 2014)

RECENT RESEARCH PROJECTS/PROBLEMS

- [Diffusion Tensor-based Computational Algorithms for White Matter Fibers Detection in Brain MRI:](#)

Magnetic resonance imaging (MRI) is a method of imaging human tissues that does not require invasive procedures. Diffusion tensor imaging (DTI) is a specific MRI technique used to visualize the white matter tracts in the brain. However, DTI has limitations in detecting multiple fiber orientations. To overcome this challenge, various mixture models like the mixture of Gaussian distribution (MoG), mixture of central Wishart distribution (MoCW), and mixture of noncentral Wishart distribution (MoNCW) have been introduced. These models allow for voxel-wise multi-compartmentalization, dividing each voxel into multiple compartments to account for complex diffusion patterns in the brain. Nonetheless, these mixture model-based algorithms have not efficiently addressed the detection of crossing fibers with small separation angles. Recently, we have developed computational algorithms that can detect crossing fibers, even when they are separated by extremely small angles. Additionally, we have emphasized the importance of our algorithm being computationally efficient and robust against noise. (See publications given on sl. no. 1, 2, 4, 7 and 9 in the selected publications list)

- [Efficient Algorithms for Classical and Quantum Visual Cryptography \(Image Encryption and Secret Sharing\):](#)

Our work in this direction showcases the efforts made in creating innovative algorithms for encrypting digital images. These algorithms are designed by utilizing various chaotic maps and their ergodic properties. Moreover, concepts from Numerical linear algebra and machine learning, such as compressed sensing, Singular Value Decomposition, and NMF, are incorporated into the design of encryption protocols. Furthermore, a significant amount of work has been conducted on developing a quantum image encryption algorithm based on the quantum formulation of a discrete chaotic map. Recently, multiple algorithms have been introduced for quantum secret sharing schemes, which have applications in visual cryptography. These algorithms successfully address several limitations present in the existing algorithms. (See publications given on sl. no. 3, 6, 8, 11-14, 17 in the selected publications list)

- [Computational Algorithms for solving Ill-posed problems in Imaging \(Image Restoration and Optical Flow via ML and other approaches\):](#)

In the field of applied mathematics, there has been a significant trend over the past thirty years in employing partial differential equations (PDEs) to address the challenges posed by ill-posed problems in image processing. Three fundamental types of PDE imaging models exist: linear, anisotropic, and nonlinear, which are utilized in image restoration. These methods are known for their accuracy, efficiency, and stability. We present regularized PDE models for image restoration, segmentation, super resolution, optical flow, and disparity estimation. These models effectively reduce the "staircase effect" while preserving fine details and maintaining stability. Furthermore, algorithms incorporating parallel processing and deep networks have been introduced to expedite image processing applications. Additionally, we have demonstrated some applications of applying PDE and deep learning-based models to localize and track cloud/storm motion from satellite imaging data. (See publications given on sl. no. 5, 10, 15, 16, 18 and 19-22 in the selected publications list)

- [Adaptive Training Algorithms for Neural Networks and Decision Trees Training:](#)

Neural networks and decision trees are extensively utilized in both research and industry for the classification and regression of data. However, their wider application faces obstacles due to various technical considerations. Decision trees employ single-feature-based splits to classify data, which can lead to overfitting and consequently result in degraded performance. On the other hand, neural networks (specifically multilayer perceptron) possess strong generalization capabilities but require the selection of multiple parameters for different contexts, such as the learning rate, weight values, and network architecture (number of hidden layers and nodes in each layer). Existing literature has addressed these issues by suggesting the use of single-feature-based splits when perceptron fails to generalize. This approach guarantees the convergence of the tree building process but may result in deeper and unbalanced trees. We explore such scenarios and propose solutions to achieve balanced and compact tree structures.

PUBLICATIONS SUMMARY

Category Review/Revision	Published/Accepted	Under
Refereed Journal Papers	52	05
Refereed Conference Papers	13	01
Book Chapters	04	00
Book/Proceedings Edited	03	00

LIST OF SELECTED JOURNAL PUBLICATIONS

1. A. Puri and S. Kumar, An iterative algorithm for computing gradient directions for white matter fascicles detection in brain MRI, *Phys. Eng. Sci. Med.* 46(1):165-178 (2023)
2. A. Puri and S. Kumar, A generalized order mixture model for tracing connectivity of white matter fascicles complexity in brain from diffusion MRI, *Math. Med. and Biol.* (2023)
3. D. Rathi and S. Kumar, A d-level quantum secret sharing scheme with cheat-detection (t,m) threshold, *Quantum Information processing* (2023)
4. A. Puri and S. Kumar, "A fractional order-based mixture of central Wishart (FMcCW) model for reconstructing white matter fibers from diffusion MRI", To be appeared in *Psychiatry Research: Neuroimaging* (2023)
5. M. Lakra and S. Kumar, Solving a generalized order improved diffusion equation of image denoising using a CeNN-based scheme. *Multimed Tools Appl* 81:32393–32420 (2022)
6. F. Musanna and S. Kumar, Quantum Secret Sharing using GHZ State Qubit Positioning and Selective Qubits Strategy with Simulation and Analysis, *Int. Journal of Theoretical Physics*, 61: 255 (2022)
7. A. Puri and S. Kumar, An OMP-TV2 Algorithm for Detecting White Matter Fibers in Brain MRI, *Psychiatry Research: Neuroimaging* 321, 111448 (2022)
8. F. Musanna, D. Dangwal & S. Kumar, Novel Image Encryption Algorithm using Fractional Chaos and Cellular Neural Network, *J Ambient Intell Human Comput*, 13:2205–2226 (2022)
9. A. Puri, S. Shakya, and S. Kumar, An Enhanced Multi-Fiber Reconstruction Technique using Adaptive Gradient Directions coupled with MoNCW Model in Diffusion MRI, *Journal of Magnetic Resonance*, 325: 106931 (2021)
10. M. Lakra, S. Kumar, A fractional-order PDE-based contour detection model with CeNN scheme for medical images. *J Real-Time Image Proc*, 19:147–160 (2022)
11. Musanna and S. Kumar, A Novel Three Party Quantum Secret Sharing Scheme based on Bell State Sequential Measurements with Applications in Quantum Image Sharing, *Quantum Inf Process* 19: 348 (2020)
12. F. Musanna and S. Kumar, Image encryption using Quantum 3-D Baker map and Generalized Gray code coupled with fractional Chen's chaotic system, *Quantum Inf Process* (2020) 19:220
13. F. Musanna and S. Kumar, Novel Image Encryption Algorithm using Chaotic Compressive Sensing and Nonlinear Exponential Function, *Journal of Information Security and Applications*, 54:102560 (2020)
14. F. Musanna and S. Kumar, Generating Visually Coherent Encrypted Images with Reversible Data Hiding in Wavelet Doamin by Fusing Chaos and Pairing Functions, *Computer Communications*, 162: 12-30 (2020)
15. M. Lakra and S. Kumar, A CNN-based computational algorithm for nonlinear image diffusion problem. *Multimed Tools Appl*, 79: 23887–23908 (2020)

16. S. Shakya, S. Kumar and M. Goswami, Deep Learning Algorithm for satellite imaging-based cyclone detection, *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 13(1): 827-839 (2020)
17. F. Musanna, D. Dangwal, S. Kumar and V. Malik, A Chaos Based Image Encryption Algorithm based on Multiresolution Singular Value Decomposition and a Symmetric Attractor, *The Imaging Science Journal (Royal Photographic Society)*, 68(1): 24-40 (2020)
18. S. Shakya and S. Kumar, Characterizing and predicting the movement of clouds using fractional-order optical flow, *IET Image Processing*, 13(8):1375 – 1381 (2019)
19. S. Nandal and S. Kumar, Single image fog removal algorithm in spatial domain using fractional order anisotropic diffusion. *Multimed Tools Appl* (2019) 78:10717–10732 Impact Factor: 2.757
20. Deepika Saini, Sanjeev Kumar and T. R. Gulati, NURBS-based Geometric Inverse Reconstruction of Freeform Shaped Objects, *JKSU-Computer and Information Sciences*, 29(1):116-133 (2017)
21. D. Saini, S. Kumar and T. R. Gulati, Reconstruction of Freeform Space Curves using NURBS-Snakes based Energy Minimization Approach, *Computer Aided Geometric Design*, 33: 30-45 (2015)
22. S. Kumar, S. Kumar, N. Sukavanam and R. Balasubramanian, Dual Tree Fractional Quaternion Wavelet Transform for Disparity Estimation, *ISA Transactions*, 53(2): 547-559 (2014)
23. A. Rani, S. Kumar, C. Micheloni, G.L. Foresti,, Incorporating Linear Discriminant Analysis in Neural Tree for Multidimensional Splitting, *Applied Soft Computing*, 13(10): 4219–4228 (2013)
24. S. Kumar and A. Rani, DF-LDA Tree: A Nonlinear Multilevel Classifier for Pattern Recognition, *Journal of Experimental and Theoretical Artificial Intelligence*, 25(2): 177-188 (2013)
25. C. Micheloni, A. Rani, S. Kumar and G. L. Foresti, A Balanced Neural Tree for Pattern Classification, *Neural Network Journal*, 27: 81-90 (2012)
26. S. Kumar, C. Micheloni, C. Piciarelli and G. L. Foresti, Stereo Rectification of Uncalibrated and Heterogeneous, *Pattern Recognition Letters*, 31: 1445-1452 (2010)

A detailed list of all publications are available at:

<https://www.iitr.ac.in/~MA/Malikfma>

<https://scholar.google.co.in/citations?user=FWH8EFkAAAAJ&hl=en>

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