

Lecture Notes in Networks and Systems 915

Nikhil Kumar Marriwala

Sunil Dhingra

Shruti Jain

Dinesh Kumar *Editors*

# Mobile Radio Communications and 5G Networks


Proceedings of Fourth MRCN 2023

 Springer

# Lecture Notes in Networks and Systems

Volume 915

## Series Editor

Janusz Kacprzyk , Systems Research Institute, Polish Academy of Sciences, Warsaw, Poland

## Advisory Editors

Fernando Gomide, Department of Computer Engineering and Automation—DCA, School of Electrical and Computer Engineering—FEEC, University of Campinas—UNICAMP, São Paulo, Brazil

Okyay Kaynak, Department of Electrical and Electronic Engineering, Bogazici University, Istanbul, Türkiye

Derong Liu, Department of Electrical and Computer Engineering, University of Illinois at Chicago, Chicago, USA

Institute of Automation, Chinese Academy of Sciences, Beijing, China

Witold Pedrycz, Department of Electrical and Computer Engineering, University of Alberta, Alberta, Canada

Systems Research Institute, Polish Academy of Sciences, Warsaw, Poland

Marios M. Polycarpou, Department of Electrical and Computer Engineering, KIOS Research Center for Intelligent Systems and Networks, University of Cyprus, Nicosia, Cyprus

Imre J. Rudas, Óbuda University, Budapest, Hungary

Jun Wang, Department of Computer Science, City University of Hong Kong, Kowloon, Hong Kong

The series “Lecture Notes in Networks and Systems” publishes the latest developments in Networks and Systems—quickly, informally and with high quality. Original research reported in proceedings and post-proceedings represents the core of LNNS.

Volumes published in LNNS embrace all aspects and subfields of, as well as new challenges in, Networks and Systems.

The series contains proceedings and edited volumes in systems and networks, spanning the areas of Cyber-Physical Systems, Autonomous Systems, Sensor Networks, Control Systems, Energy Systems, Automotive Systems, Biological Systems, Vehicular Networking and Connected Vehicles, Aerospace Systems, Automation, Manufacturing, Smart Grids, Nonlinear Systems, Power Systems, Robotics, Social Systems, Economic Systems and other. Of particular value to both the contributors and the readership are the short publication timeframe and the world-wide distribution and exposure which enable both a wide and rapid dissemination of research output.

The series covers the theory, applications, and perspectives on the state of the art and future developments relevant to systems and networks, decision making, control, complex processes and related areas, as embedded in the fields of interdisciplinary and applied sciences, engineering, computer science, physics, economics, social, and life sciences, as well as the paradigms and methodologies behind them.

Indexed by SCOPUS, INSPEC, WTI Frankfurt eG, zbMATH, SCImago.

All books published in the series are submitted for consideration in Web of Science.

For proposals from Asia please contact Aninda Bose ([aninda.bose@springer.com](mailto:aninda.bose@springer.com)).


Nikhil Kumar Marriwala · Sunil Dhingra ·  
Shruti Jain · Dinesh Kumar  
Editors


# Mobile Radio Communications and 5G Networks

Proceedings of Fourth MRCN 2023

 Springer

*Editors*

Nikhil Kumar Marriwala   
Department of Electronics  
and Communication Engineering  
University Institute of Engineering  
and Technology  
Kurukshetra University  
Kurukshetra, Haryana, India

Shruti Jain   
Department of Electronics  
and Communication Engineering  
Jaypee University of Information  
Technology  
Solan, Himachal Pradesh, India

Sunil Dhingra  
University Institute of Engineering  
and Technology  
Kurukshetra University  
Kurukshetra, Haryana, India

Dinesh Kumar  
Department of Electrical and Computer  
System Engineering  
RMIT University  
Melbourne, VIC, Australia

ISSN 2367-3370

ISSN 2367-3389 (electronic)

Lecture Notes in Networks and Systems

ISBN 978-981-97-0699-0

ISBN 978-981-97-0700-3 (eBook)

<https://doi.org/10.1007/978-981-97-0700-3>

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Singapore Pte Ltd. 2024

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.

The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Paper in this product is recyclable.

# Preface

Welcome to the rapidly evolving realm of Mobile Radio Communications and 5G Networks—a comprehensive exploration of the transformative landscape that defines our interconnected world. In an era where communication technologies continue to shape the way we live, work, and connect, this book endeavors to provide a nuanced understanding of the intricate dynamics that underlie mobile radio communications and the revolutionary impact of 5G networks. The journey through this book begins with an insightful overview of the historical evolution of mobile radio communications, tracing its roots from the early days of wireless telegraphy to the current era of unprecedented connectivity. The narrative unfolds to capture the pivotal moments and technological milestones that have propelled the field forward, laying the groundwork for the cutting-edge solutions that define our present and shape our future. This revolutionary leap in wireless technology transcends the boundaries of its predecessors, promising not only faster data rates but also ushering in a new era of connectivity marked by ultra-low latency, massive device connectivity, and unprecedented reliability. This book aims to serve for, industry research professionals who are currently working in the field of academia research and research industry to improve the lifespan of the general public in the area of recent advances and upcoming technologies and other emerging broadband wireless networks, WLAN, WPAN, and other homes/personal networking technologies, Pervasive and wearable computing and networking, Small cells and femtocell networks, Wireless mesh networks, Vehicular wireless networks, Cognitive radio networks and their applications, Wireless multimedia networks, Green wireless networks, Standardization activities of emerging wireless technologies Power management, Signal Processing and energy conservation techniques.

Readers will explore the technical intricacies of 5G networks, dissecting the architecture, protocols, and key enabling technologies that form the backbone of this transformative communication paradigm. Beyond the technicalities, this book also delves into the practical implications and real-world applications of mobile radio communications and 5G networks. From smart cities and autonomous vehicles to the Internet of Things (IoT) and augmented reality, the impact of these technologies on diverse sectors of society is far-reaching. Understanding these implications is

crucial for stakeholders ranging from engineers and researchers to policymakers and business leaders. In assembling this book, our goal is to provide a comprehensive resource that bridges the gap between theory and practice, offering a holistic perspective on the intricate world of mobile radio communications and 5G networks. For the proper review of each manuscript, every received manuscript was first checked for plagiarism and then the manuscript was sent to three reviewers. In this process, the committee members were involved and the whole process was monitored and coordinated by the General Chair. The Technical Program Committee involved senior academicians and researchers from various reputed institutes. The members were from India as well as abroad. The technical program mainly involves the review of the manuscript.

An overwhelming response was received from the researchers, academicians, and industry from all over the globe such as **USA, France, Germany, Oman, Malaysia, Nigeria**, etc. The manuscripts were received from pan-India with places such as **Punjab, Himachal, Uttar Pradesh, Maharashtra, Tamil Nadu, Chhattisgarh, Telangana, Rajasthan, Uttrakhand, Kerala, Odisha, Rajasthan, Uttar Pradesh, Delhi, J&K, Andhra Pradesh**, etc. The authors from premium institutes IITs, NITs, Central Universities, NSIT, PU, and many other reputed institutes participated in the conference. The conference has had an acceptance ratio of **16.5%**. Organizers of MRCN 2023 are thankful to University Institute of Engineering and Technology, Kurukshetra University, Kurukshetra (UIET, KUK), which was established by Kurukshetra University in 2004 to develop as a “Centre of Excellence” and offer quality technical education and to undertake research in Engineering and Technology for providing the necessary resources to organize such a mega event. UIET, KUK under the dynamic leadership of **Prof. (Dr.) Som Nath Sachdeva**, Honorable Vice-Chancellor, Kurukshetra University, Kurukshetra, and **Prof. (Dr.) Sunil Dhingra**, Director UIET, KUK, has established itself as a role model for Engineering and Technology Education not only for the State of Haryana but for the world over to meet the challenges of the 21st century.

The editors would like to express their sincere gratitude to the Patron of the Conference MRCN-2023 and Honorable Vice-Chancellor, Kurukshetra University, Kurukshetra Prof. (Dr.) Som Nath Sachdeva, Director UIET, KUK, and Dean Engineering and Technology Kurukshetra University, Kurukshetra, and Convener of the Conference Prof. (Dr.) Sunil Dhingra, Dean of Colleges, KUK Prof. (Dr.) Anil Vohra, Keynote speakers Dr. Dinesh Kant Kumar, Professor at RMIT University, Melbourne, Dr. Rangaraj M. Rangayyan, Professor Emeritus of Electrical and Computer Engineering, University of Calgary, Alberta, Canada, Dr. Utkarsh Srivastava, Western Michigan University, USA, Dr. S. Jagannatham, Missouri University of Science and Technology, USA, Dr. Shivakumar Mathapathi, Adjunct Faculty—Santa Clara University and UC San Diego Extension, Co-Founder of Dew Mobility USA, Co-Coordinator of MRCN-2023 Dr. Vijay Garg, all the General chairs, Plenary speakers, Invited Keynote speakers, Reviewers, Technical Programme Committee members, International Advisory Committee members, and Local Organizing, Committee members of MRCN-2023; without whose support, the quality and standards of the conference could not be maintained. Special thanks to **Mr. Aninda Bose** Executive

Editor, Springer Nature Group and his team for their valuable support and guidance. Over and above, we would like to express our deepest sense of gratitude to UIET, Kurukshetra University, Kurukshetra, for hosting this conference.

We extend our gratitude to the contributors, researchers, and industry experts whose insights and expertise have enriched the content and ensured the relevance of this volume. As we navigate the pages that follow, let us embark on a journey of discovery—one that transcends technological boundaries, embraces innovation, and sheds light on the future of communication. Mobile Radio Communications and 5G Networks beckon, and the possibilities they unfold are as limitless as the human imagination. We extend our heartfelt gratitude to **Springer** for their unwavering commitment to academic excellence and for bringing the proceedings of our research to a global audience.

Kurukshetra, India  
Kurukshetra, India  
Solani, India  
Melbourne, Australia

Nikhil Kumar Marriwala  
Sunil Dhingra  
Shruti Jain  
Dinesh Kumar



# Contents

<b>Deep Learning Assisted Diagnosis of Parkinson’s Disease</b> .....	1
Vipransh Aggarwal, Shruti Jain, Monika Bharti, Himanshu Jindal, Rohan Rana, and Vibhav Ahuja	
<b>Deep Learning: How to Apply Machine Learning and Deep Learning Methods to Audio Analysis</b> .....	11
Manan Dabral, Tejinder Kaur, Abhay Khanna, Ashish Yadav, Ojas Sharma, and Nakul	
<b>Naive Bayes Classifier-Based Smishing Detection Framework to Reduce Cyber Attack</b> .....	23
Gaganpreet Kaur, Kiran Deep Singh, Jatin Arora, Susama Bagchi, Sanjoy Kumar Debnath, and A. V. Senthil Kumar	
<b>A Novel System for Finding Shortest Path in a Network Routing Using Hybrid Evolutionary Algorithm</b> .....	35
Tejinder Kaur and Jimmy Singla	
<b>Emotion Analysis and Gender Identification Using Partial Face Detection</b> .....	53
Premanand P. Ghadekar, Vishal Govindani, Tanmay Mutalik, Kuhu Mukhopadhyay, and Amey Chopde	
<b>Data Security Threats Arising Between a Cloud and Its Users</b> .....	65
Anuj Kumar Gupta and Monika Pathak	
<b>Machine Learning Assisted Software Transplantation: A Baseline Technique</b> .....	75
Gurjot Singh Sodhi and Dhavleesh Rattan	
<b>Gold and Silver Price Prediction in Indian Market Using Machine Learning Algorithm</b> .....	103
Neha Madaan, Pradeepta Kumar Sarangi, Prazy Jindal, and Monica Dutta	

**Fog-centric IoT Smart Healthcare: Architecture, Applications, and Case Study** ..... 123  
 Divya Gupta, Ankit Bansal, Shivani Wadhwa, and Syed Hassan Ahmed Shah

**Responsive Mechanism for Cloud Offloading Data Intrusion Detection Using Spark—Machine Learning Model** ..... 133  
 Hari Shankar Punna and Arif Mohammad Abdul

**Impact of COVID-19 on People** ..... 149  
 Neha Nandal, Rohit Tanwar, Meduri Saketh, and Urmila Pilonia

**Video Analysis Using Deep Learning in Smart Gadget for Women Saftey** ..... 165  
 W. Irene Michelle, M. Z. Mohamed Ashik, N. Achyut, T. Nitya, Deepa Jose, and Jerold Kingston Gnanasekaran

**Compression of Medical Images Using Lifting Haar Wavelet Transform for Teleradiology Applications** ..... 175  
 Linu Tess Antony and S. N. Kumar

**Leveraging Content Based Image Retrieval Using Data Mining for Efficient Image Exploration** ..... 187  
 Jaspreet Kaur, Divya Gupta, Amrinder Singh, and Syed Hassan Ahmed Shah

**Image Enhancement and Restoration: Deep Learning for Image Dehazing** ..... 195  
 Parmeet Kaur and Sandhya Bansal

**Hate Speech Detection in Social Media Using Ensemble Method in Classifiers** ..... 209  
 R. Sathishkumar, M. Govindarajan, and R. Deepankumar

**Detection and Classification of Neuro-Degenerative Disease via EfficientNetB7** ..... 223  
 R. Sathishkumar, M. Govindarajan, and R. Dhivyasri

**An Empirical Study of Rainfall Prediction Using Various Regression Models** ..... 235  
 Deepika Vodnala, Vemula Laxmi Sathvika, Kodithyala Sai Venkat, and Dasari Joseph Anand Chowdary

**A Novel Ensemble Approach for Colon Cancer Detection Over the Multiclass Colon Dataset** ..... 247  
 Puneshkumar U. Tembhare, Raj Thaneeghaivel, and Versha Namdeo

**Area and Energy Efficient Booth Radix-4 Signed Multiplier Using Verilog** ..... 263  
 Priyanka Kumari and Gaurav Verma

**Enhancing Power Quality Improvement Using Model Predictive Controlled System with DPFC** ..... 273  
 Akhib Khan Bahamani, G. Srinivasulu Reddy, and G. V. K. Murthy

**Leveraging Machine Learning for Comprehensive Analysis of Maternal Health: Predicting Health Risks and Improving Antenatal Care** ..... 287  
 Raj Gaurang Tiwari, Ambuj Kumar Agarwal, and Vishal Jain

**Enhancing Information Security for Text-Based Data Hiding Using Midpoint Folding Approach: A Comparative Analysis** ..... 299  
 Sachin Allwadhi, Kamaldeep Joshi, and Ashok Kumar Yadav

**Design and Parametric Variation Assessment of Extended Source Double Gate Tunnel Field-Effect Transistor (ESDGTfET) for Enhanced Performance** ..... 309  
 Vedvrat, Vidyadhar Gupta, and Rohit Tripathi

**A Review on Facial Anti-spoofing Techniques** ..... 323  
 Veerpal Kaur, Prashant Kumar, Ashima Kukkar, Gagandeep Kaur, and Amandeep Kaur

**Effect of Various Structure Parameters on Electrical Characteristics of Double Gate FinFET** ..... 337  
 Suruchi Saini and Hitender Kumar Tyagi

**Climate Change Impacts on Vaitarna River Basin Hydrology Using Downscaling Machine Learning Technique** ..... 347  
 M. K. Deshmukh

**An Intelligent Breast Cancer Classification and Prediction Model Using Deep Learning Approach** ..... 363  
 Deepti Sharma, Rajneesh Kumar, and Anurag Jain

**Significant Factors for Recommender Systems Using Sentimental Analysis** ..... 371  
 Rachita Kansal and Chander Diwaker

**Comprehensive Analysis of Enterprise Blockchain: Hyperledger Fabric/Corda/Quorum: Three Different Distributed Ledger Technologies for Business** ..... 383  
 Arshad A. Dar, Faheem Ahmad Reegu, and Gousiya Hussain

**A Fast and Efficient Deep Learning Aided Diagnosis of Breast Cancer Using Histopathological Images** ..... 397  
 S. Bhuvanewari and S. Karthikeyan

**Performance Examination of Relay Supported Cooperative NOMA Network** ..... 415  
 Nidhi Chaudhary, Niraj Partap Singh, and Gaurav Verma

**Brain MRI Images for Tumour Detection Using Storage Optimisation Technique** ..... 425  
 Ramdas Vankdothu and Mohd Abdul Hameed

**Design and Analysis of U-Slot Microstrip Patch Antenna for ISM Band Applications** ..... 439  
 Purushottam Lal Nagar, Shrish Bajpai, and Digvijay Pandey

**Assessing the Impact of Various Machine Learning Algorithms for Heart Disease Prediction** ..... 453  
 Deepika Arora, Avinash Sharma, and B. K. Agrawal

**Multi-agent-Based Load Balancing in Mobile Edge Computing** ..... 469  
 Aarti Sharma and Chander Diwaker

**User Association in 5G HetNets** ..... 479  
 Sanjana Dyavappanavar, Abhay Shirol, M. Vijayalakshmi, Anusha Chikkamath, Sanjeevini Gundagatti, and Vaishnavi Torgal

**Smart Glasses for Blind Using Text-To-Speech** ..... 495  
 Sonali M. Antad, Gaurav G. Khochare, Shantanu S. Khopade, Pratik N. Khinde, Sachi D. Khobragade, and Sampada R. Khopade

**Fake News Detection Using SRTD Algorithm** ..... 505  
 Mahek and Dr. Sanjay Tyagi

**Grapevine Leaf Disease Classification with Deep Learning and Feature Extraction Using IoT** ..... 519  
 Isha Kansal, Vivek Bhardwaj, Jyoti Verma, Vikas Khullar, Renu Popli, and Rajeew Kumar

**Evaluation and Comparison of Routing Protocols for Internet of Vehicles (IoV) Environment** ..... 527  
 Ishita Seth, Kalpna Guleria, and Surya Narayan Panda

**Deep Neural Networks Performance Comparison for Handwritten Text Recognition** ..... 539  
 Anjani Kumar Singha, Manaswini Jena, Swaleha Zubair, Pradeep Kumar Tiwari, and Abhay Pratap Singh Bhadauria

**Applying Deep Hybrid Neural Network for Image Classification** ..... 555  
 Anita Venugopal, Aditi Sharma, and Gajender Kumar

**Experimental Analysis of Emotion Recognition in Voice Using MFCC and Deep Neural Network** ..... 561  
 Monika Khatkar, Asha Sohal, and Ramesh Kait

**Empirical Analysis of Machine Learning in Enhancing the E-Business Through Structural Equation Modeling** ..... 575  
 P. William, Md. Rageeb, Md. Usman Roja Boina, T. R. Vijaya Lakshmi, Ashish Sharma, and Nikhil Kumar Marriwala

**Integration of Secure Data Communication with Wireless Sensor Network Using Cryptographic Technique** ..... 589  
 P. William, Narender Chinthamu, Aditi Saxena, T. R. Vijaya Lakshmi, and Mohit Tiwari

**Comparative Analysis of Data Mining Based Performance Evaluation Using Hybrid Deep Learning Approach** ..... 607  
 Gurpreet Singh Chhabra, P. William, Govinda Rajulu Lanke, Kirti Jain, T. R. Vijaya Lakshmi, and Neeraj Varshney

**Probing of Instructional Data Mining Effectiveness in Decision-Making for Industrial and Educational Applications** ..... 623  
 Pravin B. Khatkale, P. William, Oluwadare Joshua Oyebode, Aman Sharma, Vandana Kumari, and Vikram Singh

**Assessment of Wireless Sensor Networks Integrated with Various Cluster-Based Routing Protocols** ..... 643  
 P. William, Narender Chinthamu, M. Chiranjivi, T. R. Vijaya Lakshmi, Rakesh Kumar, and Nikhil Kumar Marriwala

**A Predictive Modeling to Assess the Underlying Risks of Stroke** ..... 655  
 Shawni Dutta, Samir Kumar Bandyopadhyay, Midhunchakkaravarthy Janarthanan, Payal Bose, and Digvijay Pandey

**An Analysis of Brain Tumor Segmentation and Classification Techniques of Deep Learning** ..... 667  
 Amar Saraswat, Shweta Bansal, and Anupam Dalal

**Assessment of Various MapReduce Scheduling in Heterogeneous Environment** ..... 677  
 Sonia Sharma and Rajendra Kumar Bharti

**Internet of Medical Things: A Revolution in Healthcare Towards Assistive Living** ..... 687  
 Lipakshi, Simran Ghai, Tanish Kapoor, Savita Wadhawan, and Arvind K. Sharma

**Analyzing the Impact of Oversampling on Classifier Performance for Cardiac Disease Classification** ..... 723  
 Savita Wadhawan, Raman Maini, and Balwinder Singh

**A Hybrid Approach for Allocating Resources and Scheduling Task in Cloud Computing** ..... 741  
 Ajay Jangra and Professor Neeraj Mangla

**Intelligent Feature Engineering and Feature Selection Techniques for Machine Learning Evaluation** ..... 753  
 Janjhyam Venkata Naga Ramesh, Ajay kushwaha, Tripti Sharma, A. Aranganathan, Ankur Gupta, and Sanjiv Kumar Jain

**Health Fitness Tracker System Using Machine Learning Based on Data Analytics** ..... 765  
Vivek Veeraiah, Janjhyam Venkata Naga Ramesh, Ashok Koujalagi, Veera Talukdar, Arpit Namdev, and Ankur Gupta

**A Machine Learning Forecast of Renewable Solar Power Generation and Analysis of Distribution and Management Using IOT-Based Sensor Data** ..... 777  
Mamta Sharma, Taviti Naidu Gongada, Rohit Anand, Nidhi Sindhwani, Reshma Ramakant Kanse, and Ankur Gupta

**Neural Network Model for Gas Classification of Semiconductor-Based Heterogeneous Gas Sensors Arrays** ..... 789  
Rahul Gupta, Pradeep Kumar, and Dinesh Kumar

**Secured Quantum Communication of Entangled State as a Quantum Channel** ..... 797  
Simranjot Kaur and Savita Gill

# Editors and Contributors

## About the Editors

**Dr. Nikhil Kumar Marriwala** is working as an Assistant Professor Electronics and Communication Engineering Department, the University Institute of Engineering and Technology, Kurukshetra University, Kurukshetra. He did his Ph.D. from the National Institute of Technology (NIT), Kurukshetra, in the department of ECE. He has more than 21 years of experience teaching graduate and postgraduate students. More than 33 students have completed their M.Tech. dissertation under his guidance. He has published more than five book chapters in different International books, has authored more than 10 books with Pearson, Wiley, etc., and has more than 40 publications to his credit in reputed International Journals (SCI, SCIE, ESCI, and Scopus) with 20 papers in International/National conferences. He has been granted eight Patents with two Indian patents and six International Patents. He has been Chairman of Special Sessions in more than 22 International/National Conferences and has delivered a keynote address at more than nine International conferences. He has also acted as organizing secretary for more than seven International conferences and one National Conference. He has delivered more than 70 Invited Talks/Guest Lectures in leading Universities/Colleges PAN India. He is having additional charge of Training and Placement Officer, UIET, Kurukshetra University, Kurukshetra for more than 12 years now. He is the editor of more than five book proceedings with Springer and guest editor for the special session in Journal Measurement and Sensors, Elsevier. He has also been awarded as the “Career Guru of the Month” award by Aspiring Minds. His areas of interest are Software Defined Radios, Cognitive Radios, Soft Computing, Wireless Communications, Wireless Sensor Networks, Fuzzy system design, and Advanced Microprocessors.

**Dr. Sunil Dhingra** is currently serving as Dean of the Faculty of Engineering and Technology, Kurukshetra University Kurukshetra, and Director of the University Institute of Engineering and Technology (UIET), KUK. He completed his Ph.D. in the area of Semiconductor Electronics and Instrumentation. He is also having charge

of Proctor and Chief Vigilance Officer at Kurukshetra University. He is constantly at fore front lines for students and for their careers. He also held roles such as Director of IT Cell and Chairman of the Department of Instrumentation in the past. His primary aim is always to make various institutions of university to be recognized as a global centre of academic excellence.

**Dr. Shruti Jain** is an Associate Dean (Innovation) and Professor in the Department of Electronics and Communication Engineering at the Jaypee University of Information Technology, Wagnaghat, H.P., India. She has received her Doctor of Science (D.Sc.) in Electronics and Communication Engineering. She has teaching experience of around 19 years. She has filed eight patents, of which two have been granted and five are published. She has published more than 26 book chapters and 130 research papers in reputed indexed journals and international conferences. She has also published 16 books. She has completed two government-sponsored projects. She has guided seven Ph.D. students and now has five registered students. She has also guided 11 M.Tech. scholars and more than 100 B.Tech. undergrads. She has organized 14 conferences of IEEE and Springer as Conference General Chair. Her research interests are Image and Signal Processing, Soft Computing, Internet of Things, Pattern Recognition, Bio-inspired Computing, and Computer-Aided Design of FPGA and VLSI circuits. She is a senior member of IEEE, an Executive member of the IEEE Delhi Section, a life member and Executive member of the Biomedical Engineering Society of India, and a member of IAENG. She is a member of the Editorial Board of many reputed journals. She is also a reviewer of many journals and a member of TPC of different conferences. She was awarded the Nation Builder Award in 2018–2019 and enlisted in 2% scientists of world rankings of 2021 and 2023 published by Elsevier, data compiled by Stanford University.

**Prof. Dinesh Kumar** completed B.Tech. from IIT Madras and Ph.D. from IIT Delhi and is a Professor at RMIT University, Melbourne, Australia. He has published over 400 papers, authored five books, and is on a range of Australian and international committees for Biomedical Engineering. His passion is for affordable diagnostics and making a difference for his students. His work has been cited over 5600 times, and he has also had multiple successes with technology translation. He is a Member of Therapeutics Goods Administration (TGA), Ministry of Health (Australia) for medical devices. He is also on the editorial boards for IEEE Transactions of Neural Systems and Rehabilitation Engineering and Biomedical Signals and Controls. He has been Chair of a large number of conferences and given over 50 keynote speeches.

## Contributors

**Arif Mohammad Abdul** Associate Professor, Department of Computer Science and Engineering, GITAM (Deemed to be University), Hyderabad, India



**N. Achyut** Department of Electronics and Communication Engineering, KCG College of Technology, Chennai, Tamil Nadu, India

**Ambuj Kumar Agarwal** Department of Computer Science and Engineering, School of Engineering and Technology, Sharda University, Greater Noida, India

**Vipransh Aggarwal** Department of CSE & IT, Jaypee University of Information Technology, Solan, Himachal Pradesh, India

**B. K. Agrawal** M.M Institute of Medical Sciences & Research, Maharishi Markandeshwar (Deemed to Be University), Mullana, Ambala, Haryana, India

**Vibhav Ahuja** Department of CSE & IT, Jaypee University of Information Technology, Solan, Himachal Pradesh, India

**Sachin Allwadhi** Department of Computer Science and Engineering, University Institute of Engineering and Technology, Maharshi Dayanand University, Rohtak, Haryana, India

**Rohit Anand** G. B. Pant DSEU Okhla-1 Campus (Formerly G. B. Pant Engineering College), New Delhi, India

**Sonali M. Antad** Department of Engineering, Sciences and Humanities, Vishwakarma Institute of Technology, Pune, Maharashtra, India

**Linu Tess Antony** Department of Basic Science, Amal Jyothi College of Engineering, APJAKTU, Kanjirappally, Kerala, India

**A. Aranganathan** School of Electrical and Electronics, Sathyabama Institute of Science and Technology, Chennai, Tamil Nadu, India

**Deepika Arora** Department of Computer Science & Engineering, M.M Engineering CollegeMaharishi Markandeshwar (Deemed to Be University), Mullana-Ambala, Haryana, India

**Jatin Arora** Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

**M. Z. Mohamed Ashik** Department of Electronics and Communication Engineering, KCG College of Technology, Chennai, Tamil Nadu, India

**Susama Bagchi** Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

**Akhib Khan Bahamani** Department of Electrical & Electronics Engineering, Narayana Engineering College, Nellore, Andhra Pradesh, India

**Shrish Bajpai** Integral University, Lucknow, U.P, India

**Samir Kumar Bandyopadhyay** Lincoln University College, Petalling Jaya, Selangor, Malaysia

**Ankit Bansal** Chitkara University Institute of Engineering and Technology, Chitkara University, Punjab, India

**Sandhya Bansal** Department of Computer Science and Engineering, Maharishi Markandeshwar Engineering College, Maharishi Markandeshwar (Deemed to Be University) Mullana, Ambala, Haryana, India

**Shweta Bansal** Department of CSE, K. R. Mangalam University, Gurgaon, India

**Abhay Pratap Singh Bhadauria** Department of Computer Applications, SRM Institute of Science and Technology ('Deemed-to-be-University'), Delhi-NCR Campus, Ghaziabad, India;  
Gurukula Kangri (Deemed to Be University), Haridwar, India

**Vivek Bhardwaj** School of Computer Science and Engineering, Manipal University Jaipur, Jaipur, India

**Monika Bharti** Department of CSE, Amity University, Mohali, Punjab, India

**Rajendra Kumar Bharti** Department of CSE, Bipin Tripathi Kumaon Institute of Technology, Dwarahat, India

**S. Bhuvaneshwari** Sathyabama Institute of Science and Technology, Chennai, Tamil Nadu, India;  
Sri Sairam Engineering College, Chennai, Tamil Nadu, India

**Md. Usman Roja Boina** Independent Researcher, Morrisville, NC, USA

**Payal Bose** GLA University, Mathura, India

**Nidhi Chaudhary** Department of ECE, NIT Kurukshetra, Haryana, India

**Gurpreet Singh Chhabra** Department of CSE, GITAM School of Technology, GITAM University, Visakhapatnam, India

**Anusha Chikkamath** School of Computer Science and Engineering, KLE Technological University, Hubballi, India

**Narender Chinthamu** Enterprise Architect, MIT (Massachusetts Institute of Technology), CTO Candidate, Dallas, TX, USA

**M. Chiranjivi** Department of EEE, Hyderabad Institute of Technology and Management, Hyderabad, Telangana, India

**Amey Chopde** Department of Information Technology, Vishwakarma Institute of Technology, Pune, India

**Dasari Joseph Anand Chowdary** Department of Computer Science and Information Technology, CVR College of Engineering, Hyderabad, India

**Manan Dabral** Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

**Anupam Dalal** Dronacharya College of Engineering, Gurgaon, India

**Arshad A. Dar** College of Computer Science and Information Technology, Jazan University, Jizan, Saudi Arabia

**Sanjoy Kumar Debnath** Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

**R. Deepankumar** Manakula Vinayagar Institute of Technology, Puducherry, India

**M. K. Deshmukh** Department of Computer Science and Engineering, College of Engineering and Technology, Akola, Maharashtra, India

**R. Dhivyasri** Manakula Vinayagar Institute of Technology, Puducherry, India

**Chander Diwaker** Department of Computer Science and Engineering, UIET, Kurukshetra University, Kurukshetra, India;  
University Institute of Engineering and Technology, Kurukshetra, India

**Monica Dutta** Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

**Shawni Dutta** Lincoln University College, Petalling Jaya, Selangor, Malaysia

**Sanjana Dyavappanavar** School of Computer Science and Engineering, KLE Technological University, Hubballi, India

**Premanand P. Ghadekar** Department of Information Technology, Vishwakarma Institute of Technology, Pune, India

**Simran Ghai** Yogananda School of Artificial Intelligence, Computers and Data Science, Shoolini University, Solan, Himachal Pradesh, India

**Savita Gill** Department of Applied Science, University Institute of Engineering and Technology, Kurukshetra University, Kurukshetra, India

**Jerold Kingston Gnanasekaran** Eurecom Research Institution, Biot, France

**Taviti Naidu Gongada** Department of Operations, GITAM School of Business, GITAM (Deemed to Be University), Visakhapatnam, Andhra Pradesh, India

**Vishal Govindani** Department of Information Technology, Vishwakarma Institute of Technology, Pune, India

**M. Govindarajan** Annamalai University, Chidambaram, Tamilnadu, India

**Kalpna Guleria** Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

**Sanjeevini Gundagatti** School of Computer Science and Engineering, KLE Technological University, Hubballi, India

**Ankur Gupta** Department of CSE, Vaish College of Engineering, Rohtak, Haryana, India

**Anuj Kumar Gupta** Chandigarh Group of Colleges, Landran, Mohali, PB, India

**Divya Gupta** Department of Computer Science and Engineering, Chandigarh University, Mohali, India

**Rahul Gupta** J. C. Bose University of Science and Technology, YMCA, Faridabad, Haryana, India;  
University Institute of Engineering and Technology, Kurukshetra University, Kurukshetra, Haryana, India

**Vidyadhar Gupta** Department of Electronics and Communication Engineering, Pranveer Singh Institute of Technology, Kanpur, Uttar Pradesh, India

**Mohd Abdul Hameed** Department of Computer Science and Engineering, Osmania University, Hyderabad, India

**Gousiya Hussain** Department of Computer Science, Mewar University, Chittorgarh, India

**Anurag Jain** Virtualization Department, School of Computer Science, University of Petroleum and Energy Studies, Dehradun, India

**Kirti Jain** School of Advanced Computing, Sanjeev Agrawal Global Educational (SAGE) University, Bhopal, India

**Sanjiv Kumar Jain** Department of EE, Medi-Caps University, Indore, Madhya Pradesh, India

**Shruti Jain** Department of ECE, Jaypee University of Information Technology, Solan, Himachal Pradesh, India

**Vishal Jain** Department of Computer Science and Engineering, School of Engineering and Technology, Sharda University, Greater Noida, India

**Midhunchakkaravarthy Janarthanan** Lincoln University College, Petalling Jaya, Selangor, Malaysia

**Ajay Jangra** PhD scholar, Department of Computer Science and Engineering, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, India

**Manaswini Jena** Gurukula Kangri (Deemed to Be University), Haridwar, India; Birla Global University, Bhubaneswar, Odisha, India

**Himanshu Jindal** Department of CSE, Amity University, Mohali, Punjab, India

**Prazy Jindal** Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

**Deepa Jose** Department of Electronics and Communication Engineering, KCG College of Technology, Chennai, Tamil Nadu, India

**Kamaldeep Joshi** Department of Computer Science and Engineering, University Institute of Engineering and Technology, Maharshi Dayanand University, Rohtak, Haryana, India

**Ramesh Kait** Kurukshetra University, Kurukshetra, Haryana, India

**Isha Kansal** Institute of Engineering and Technology, Chitkara University,  
Chitkara University, Rajpura, Punjab, India

**Rachita Kansal** Department of Computer Science and Engineering, UIET,  
Kurukshetra University, KKR, Thanesar, India

**Reshma Ramakant Kanse** Department of Engineering and Technology, Bharati  
Vidyapeeth Deemed University, Navi Mumbai, India

**Tanish Kapoor** Yogananda School of Artificial Intelligence, Computers and Data  
Science, Shoolini University, Solan, Himachal Pradesh, India

**S. Karthikeyan** Sathyabama Institute of Science and Technology, Chennai, Tamil  
Nadu, India

**Amandeep Kaur** Department of Computer Science and Engineering, University  
of the Fraser Valley, Abbotsford, BC, Canada

**Gagandeep Kaur** Chitkara University Institute of Engineering and Technology,  
Chitkara University, Rajpura, Punjab, India

**Gaganpreet Kaur** Chitkara University Institute of Engineering and Technology,  
Chitkara University, Rajpura, Punjab, India

**Jaspreet Kaur** Department of Computer Science and Engineering, Chandigarh  
University, Mohali, India

**Parmeet Kaur** Department of Computer Science and Engineering, Maharishi  
Markandeshwar Engineering College, Maharishi Markandeshwar (Deemed to Be  
University) Mullana, Ambala, Haryana, India

**Simranjot Kaur** Department of Applied Science, University Institute of  
Engineering and Technology, Kurukshetra University, Kurukshetra, India

**Tejinder Kaur** Department of Computer Science Engineering, CT University,  
Ludhiana, Punjab, India;  
Department of Computer Science & Engineering, MMEC, Maharishi  
Markandeshwar (Deemed to Be University), Mullana, Ambala, Haryana, India

**Veerpal Kaur** Lovely Professional University, Phagwara, Punjab, India

**Abhay Khanna** Chitkara University Institute of Engineering and Technology,  
Chitkara University, Rajpura, Punjab, India

**Pravin B. Khatkale** Department of Mechatronics, Sanjivani K.B.P. Polytechnic,  
Kopergaon, India

**Monika Khatkar** K. R. Mangalam University, Gurugram, Haryana, India

**Pratik N. Khinde** Department of Engineering, Sciences and Humanities,  
Vishwakarma Institute of Technology, Pune, Maharashtra, India

**Sachi D. Khobragade** Department of Engineering, Sciences and Humanities, Vishwakarma Institute of Technology, Pune, Maharashtra, India

**Gaurav G. Khochare** Department of Engineering, Sciences and Humanities, Vishwakarma Institute of Technology, Pune, Maharashtra, India

**Sampada R. Khopade** Department of Engineering, Sciences and Humanities, Vishwakarma Institute of Technology, Pune, Maharashtra, India

**Shantanu S. Khopade** Department of Engineering, Sciences and Humanities, Vishwakarma Institute of Technology, Pune, Maharashtra, India

**Vikas Khullar** Institute of Engineering and Technology, Chitkara University, Chitkara University, Rajpura, Punjab, India

**Ashok Koujalagi** Department of CSE, Godavari Institute of Engineering and Technology (Autonomous), Rajamahendravaram, Andhra Pradesh, India

**Ashima Kukkar** Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

**Dinesh Kumar** Department of Electronic Science, Kurukshetra University, Kurukshetra, Haryana, India;  
Gurugram University, Gurugram, Haryana, India

**A. V. Senthil Kumar** Hindusthan College of Arts and Science, Coimbatore, Tamil Nadu, India

**Gajender Kumar** Department of Computer Science and Engineering, SRM Institute of Science and Technology (SRMIST), SRM University, Delhi, India

**Pradeep Kumar** J. C. Bose University of Science and Technology, YMCA, Faridabad, Haryana, India

**Prashant Kumar** Lovely Professional University, Phagwara, Punjab, India

**Rajeev Kumar** Institute of Engineering and Technology, Chitkara University, Chitkara University, Rajpura, Punjab, India

**Rajneesh Kumar** Department of Computer Science & Engineering, MMEC, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, India

**Rakesh Kumar** Department of Computer Engineering and Applications, GLA University, Mathura, India

**S. N. Kumar** Department of EEE, Amal Jyothi College of Engineering, Kanjirappally, Kerala, India

**Priyanka Kumari** School of VLSI Design and Embedded Systems, National Institute of Technology Kurukshetra, Kurukshetra, Haryana, India

**Vandana Kumari** Lloyd Institute of Engineering and Technology, Greater Noida, India

**Ajay kushwaha** Department of CSE, Rungta College of Engineering & Technology, Bhilai, Chhattisgarh, India

**Govinda Rajulu Lanke** ResMed Digital Health Technology, San Diego, CA, USA

**Lipakshi** Yogananda School of Artificial Intelligence, Computers and Data Science, Shoolini University, Solan, Himachal Pradesh, India

**Neha Madaan** Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

**Mahek** Department of Computer Science and Applications, Kurukshetra University, Kurukshetra, India

**Raman Maini** Department of CSE, Punjabi University, Patiala, India

**Professor Neeraj Mangla** Professor, Department of Computer Science and Engineering, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, India

**Nikhil Kumar Marriwala** Department of Electronics and Communication Engineering, University Institute of Engineering and Technology, Kurukshetra University, Kurukshetra, Haryana, India

**W. Irene Michelle** Department of Electronics and Communication Engineering, KCG College of Technology, Chennai, Tamil Nadu, India

**Kuhu Mukhopadhyay** Department of Information Technology, Vishwakarma Institute of Technology, Pune, India

**G. V. K. Murthy** PACE Institute of Technology and Sciences, Ongole, Andhra Pradesh, India

**Tanmay Mutalik** Department of Information Technology, Vishwakarma Institute of Technology, Pune, India

**Purushottam Lal Nagar** Integral University, Lucknow, U.P, India

**Nakul** Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

**Versha Namdeo** SRK University, Bhopal, Madhya Pradesh, India

**Arpit Namdev** Department of IT, University Institute of Technology RGPV, Bhopal, Madhya Pradesh, India

**Neha Nandal** Department of Computer Science and Engineering, Geethanjali College of Engineering and Technology, Hyderabad, India

**T. Nitya** Department of Electronics and Communication Engineering, KCG College of Technology, Chennai, Tamil Nadu, India

**Oluwadare Joshua Oyebode** Civil and Environmental Engineering, Afe Babalola University, Ado-Ekiti, Ekiti State, Nigeria

**Surya Narayan Panda** Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

**Digvijay Pandey** Department of Technical Education, Govt of U.P., Kanpur, India

**Monika Pathak** JGND Punjab State Open University, Patiala, PB, India

**Urmila Pilania** Department of Computer Science and Technology, Manav Rachna University, Faridabad, India

**Renu Popli** Institute of Engineering and Technology, Chitkara University, Chitkara University, Rajpura, Punjab, India

**Hari Shankar Punna** Research Scholar, Department of Computer Science and Engineering, GITAM (Deemed to be University), Hyderabad, Telangana, India; Assistant Professor, Department of CSE(Data Science), CVR College of Engineering, Hyderabad, Telangana, India

**Md. Rageeb** Department of Pharmacognosy, Smt. Sharadchandrika Suresh Patil College of Pharmacy, Chopda, Maharashtra, India

**Janjhyam Venkata Naga Ramesh** Department of CSE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, Andhra Pradesh, India

**Rohan Rana** Department of CSE & IT, Jaypee University of Information Technology, Solan, Himachal Pradesh, India

**Dhavllesh Rattan** Department of Computer Science and Engineering, Punjabi University, Patiala, Punjab, India

**Faheem Ahmad Reegu** College of Computer Science and Information Technology, Jazan University, Jizan, Saudi Arabia

**Suruchi Saini** Department of Electronic Science, Kurukshetra University, Kurukshetra, India

**Meduri Saketh** Department of Computer Science and Engineering, Gokaraju Rangaraju Institute of Engineering and Technology, Hyderabad, India

**Pradeepta Kumar Sarangi** Chitkara University School of Engineering and Technology, Chitkara University, Himachal Pradesh, India

**Amar Saraswat** Department of CSE, K. R. Mangalam University, Gurgaon, India

**R. Sathishkumar** Manakula Vinayagar Institute of Technology, Puducherry, India

**Vemula Laxmi Sathvika** Department of Computer Science and Information Technology, CVR College of Engineering, Hyderabad, India

**Aditi Saxena** Department of Electronics and Communication Engineering, GLA University, Mathura, India



**Ishita Seth** Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

**Syed Hassan Ahmed Shah** California State University, Fullerton, CA, USA

**Aarti Sharma** University Institute of Engineering and Technology, Kurukshetra, India

**Aditi Sharma** IEEE Senior Member, Department of Computer Science and Engineering, Symbiosis Institute of Technology, Symbiosis International (Deemed University), Pune, Maharashtra, India

**Aman Sharma** Department of Mechanical Engineering, Institute of Engineering and Technology, GLA University, Mathura, UP, India

**Arvind K. Sharma** Yogananda School of Artificial Intelligence, Computers and Data Science, Shoolini University, Solan, Himachal Pradesh, India

**Ashish Sharma** Department of Computer Engineering and Applications, GLA University, Mathura, India

**Avinash Sharma** Department of Computer Science & Engineering, M.M Engineering College Maharishi Markandeshwar (Deemed to Be University), Mullana-Ambala, Haryana, India

**Deepthi Sharma** Department of Computer Science & Engineering, MMEC, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, India

**Mamta Sharma** Department of CSE and CSA, Arni University, Kangra, Himachal Pradesh, India

**Ojas Sharma** Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

**Sonia Sharma** Department of CSE, Seth Jai Parkash Mukund Lal Institute of Engineering and Technology (JMIT), Radaur, India;  
Veer Madho Singh Bhandari Uttarakhand Technical University, Dehradun, India

**Tripti Sharma** Department of CSE, Rungta College of Engineering & Technology, Bilai, Chhattisgarh, India

**Abhay Shirol** School of Computer Science and Engineering, KLE Technological University, Hubballi, India

**Nidhi Sindhwani** Amity Institute of Information Technology, Amity University, Noida, Uttar Pradesh, India

**Amrinder Singh** University Institute of Teachers Training and Research, Chandigarh University, Mohali, Punjab, India

**Balwinder Singh** Yadavindra Department of Engineering, Punjabi University Guru Kashi Campus, Talwandi Sabo, Patiala, India

**Kiran Deep Singh** Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India

**Niraj Partap Singh** Department of ECE, NIT Kurukshetra, Haryana, India

**Vikram Singh** Quantum University, Roorkee, Uttarakhand, India

**Anjani Kumar Singha** Department of Computer Applications, SRM Institute of Science and Technology ('Deemed-to-be-University'), Delhi-NCR Campus, Ghaziabad, India;  
Gurukula Kangri (Deemed to Be University), Haridwar, India

**Jimmy Singla** Department of Computer Science Engineering, CT University, Ludhiana, Punjab, India

**Gurjot Singh Sodhi** Department of Computer Science and Engineering, Punjabi University, Patiala, Punjab, India;  
Iconic Trainer, Koenig Solutions Pvt. Ltd., Gurugram, India

**Asha Sohal** K. R. Mangalam University, Gurugram, Haryana, India

**G. Srinivasulu Reddy** Narayana Engineering College, Nellore, Andhra Pradesh, India

**Veera Talukdar** Department of Computer Science, D. Y. Patil International University, Akurdi, Pune, Maharashtra, India

**Rohit Tanwar** School of Computer Science and Engineering, University of Petroleum and Energy Studies, Dehradun, India

**Puneshkumar U. Tembhare** SRK University, Bhopal, Madhya Pradesh, India

**Raj Thaneeghaivel** SRK University, Bhopal, Madhya Pradesh, India

**Mohit Tiwari** Department of Computer Science and Engineering, Bharati Vidyapeeth's College of Engineering, Delhi, India

**Pradeep Kumar Tiwari** Gurukula Kangri (Deemed to Be University), Haridwar, India;

Birla Global University, Bhubaneswar, Odisha, India;

Department of Computer Science and Engineering, Dr. Vishwanath Karad MIT World Peace University, Pune, Pune, India

**Raj Gaurang Tiwari** Chitkara University Institute of Engineering and Technology, Chitkara University, Punjab, India

**Vaishnavi Torgal** School of Computer Science and Engineering, KLE Technological University, Hubballi, India

**Rohit Tripathi** Department of Electronics and Communication Engineering, Pranveer Singh Institute of Technology, Kanpur, Uttar Pradesh, India

**Hitender Kumar Tyagi** Department of Electronics, Institute of Integrated and Honors Studies, Kurukshetra University, Kurukshetra, India

**Dr. Sanjay Tyagi** Department of Computer Science and Applications, Kurukshetra University, Kurukshetra, India

**Ramdas Vankdothu** Department of Computer Science and Engineering, Osmania University, Hyderabad, India

**Neeraj Varshney** Department of Computer Engineering and Applications, GLA University, Mathura, India

**Vedvrat** Department of Electronics and Communication Engineering, Pranveer Singh Institute of Technology, Kanpur, Uttar Pradesh, India

**Vivek Veeraiah** Department of R&D Computer Science, Adichunchanagiri University, Mandya, Karnataka, India

**Kodithyala Sai Venkat** Department of Computer Science and Information Technology, CVR College of Engineering, Hyderabad, India

**Anita Venugopal** Department of IT Unit, Dhofar University, Salalah, Sultanate of Oman

**Gaurav Verma** Department of Electronics and Communication Engineering, National Institute of Technology Kurukshetra, Kurukshetra, Haryana, India

**Jyoti Verma** Department of Computer Science and Engineering, Punjabi University, Patiala, Punjab, India

**T. R. Vijaya Lakshmi** Mahatma Gandhi Institute of Technology, Gandipet, Hyderabad, India

**M. Vijayalakshmi** School of Computer Science and Engineering, KLE Technological University, Hubballi, India

**Deepika Vodnala** Department of CSE (Cyber Security), CVR College of Engineering, Hyderabad, India

**Savita Wadhawan** M.M. Institute of Computer Technology and Business Management, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana, India;  
Department of CSE, Punjabi University, Patiala, India

**Shivani Wadhwa** Chitkara University Institute of Engineering and Technology, Chitkara University, Punjab, India

**P. William** Department of Information Technology, Sanjivani College of Engineering, Kopergaon, India;  
Department of Information Technology, Sanjivani College of Engineering, Savitribai Phule Pune University, Pune, India

**Ashish Yadav** Chitkara University Institute of Engineering and Technology,  
Chitkara University, Rajpura, Punjab, India

**Ashok Kumar Yadav** Amity School of Engineering and Technology, Amity  
University, Noida, Uttar Pradesh, India

**Swaleha Zubair** Department of Computer Applications, SRM Institute of Science  
and Technology ('Deemed-to-be-University'), Delhi-NCR Campus, Ghaziabad,  
India;  
Gurukula Kangri (Deemed to Be University), Haridwar, India;  
Computer Science, Aligarh Muslim University (AMU), Aligarh, India

# Deep Learning Assisted Diagnosis of Parkinson's Disease



Vipransh Aggarwal, Shruti Jain, Monika Bharti, Himanshu Jindal, Rohan Rana, and Vibhav Ahuja

**Abstract** A neurodegenerative condition that affects the elderly is Parkinson's disease (PD). A crucial first step in giving quick medical attention is the early diagnosis of PD. The field of artificial intelligence has recently paid increased attention to computer-assisted approaches for PD identification. The suggested method is a strong contender for identifying PD patients. The results of PD symptom monitoring using cost-effective computer tools are useful in telemedicine applications. In this paper, a model is designed to detect PD using an online dataset. Images were resized and analyzed which were classified using the Convolution Neural network (CNN). In novelty, the use of the Nearest Neighbor is used in the Pooling layer. 93% accuracy is attained using the proposed model which results in a 12.9% improvement over other state-of-the-art techniques.

**Keywords** Parkinson's disease · Convolution Neural network

## 1 Introduction

Parkinson's disease (PD) is a neurodegenerative disorder, or neurological system or degenerative disorder of the central nervous system. It is illustrated by indications like postural instability, tremors at rest, rigidity, and bradykinesia. A scarcely noticeable tremor in one hand could be the first sign [1, 2]. Although tremors are typical, the disease can also produce stiffness or slowdowns in movement. In Western

---

V. Aggarwal · R. Rana · V. Ahuja

Department of CSE & IT, Jaypee University of Information Technology, Solan, Himachal Pradesh, India

S. Jain (✉)

Department of ECE, Jaypee University of Information Technology, Solan, Himachal Pradesh, India

e-mail: [jain.shruti15@gmail.com](mailto:jain.shruti15@gmail.com)

M. Bharti · H. Jindal (✉)

Department of CSE, Amity University, Mohali, Punjab, India

e-mail: [himanshu19j@gmail.com](mailto:himanshu19j@gmail.com)

Europe, the prevalence of PD, also known as, is 160/100,000, or about 4% of the population over the age of 80. PD is also known as Parkinsonian syndrome, Asynucleinopathy, Parkinsonism, paralysis agitans, shaking palsy, or Hypokinetic Rigid Syndrome (HRS) [3, 4]. Nerve cell damage in the brain causes dopamine levels to drop, leading to the symptoms of Parkinson's [5]. It is a progressive degenerative disease of the brain due to the loss of dopamine-producing cells. PD is very difficult to diagnose as there is no standard test [6, 7]. No two people have the same set of symptoms. The symptoms of PD are similar to the symptoms of other diseases, leading to higher chances of misdiagnosis [8]. PD is difficult to diagnose because it has so many different symptoms and each person has a combination of symptoms. Tremor is the most obvious, but there is far more Essential Tremor than Parkinson's tremor so it's not a conclusive indicator. Before diagnosis one may feel pain in the extremities, cramping, loss of smell, and sleep disturbances [9, 10]. Many symptoms would cause someone to seek out the help of a different kind of doctor who is unfamiliar with Parkinson's. Someone with PD may be treated for years with a diagnosis of another malady before a neurologist who is a movement disorder specialist finally recognizes their PD [11, 12]. Parkinson's disease occurs when nerve cells (neurons) in the basal ganglia (an area of the brain that controls movement) (as shown in Fig. 1) [13] become dying or impaired. These nerve cells produce dopamine, a brain chemical that causes the movement problems of Parkinson's.

Simons et al. carried out one of the earliest investigations on FEE in Parkinson's sufferers [14]. They employed social interaction movies to elicit reactions from patients. Facial measurements, self-questionnaires, and subjective measurements based on the Facial Action Units (FAUs) are described to record the films. 44 individuals were examined by the authors in total (25 healthy controls and 19 PD patients). According to the study's findings, patients are less able to produce spontaneous facial expressions. Based on the patients' bradykinesia, Bowers et al. [15] concluded that the patients' deliberate facial expressions would be slower and smaller in amplitude than those of healthy controls in 2006. The entropy in temporal variations of the frames was determined after a frame-by-frame analysis of the patient's movies. The findings demonstrated that entropy was higher in healthy controls than in the sick. The patients took longer to attain a peak in their facial expression, according

**Fig. 1** Basal ganglia in Brain [13]

